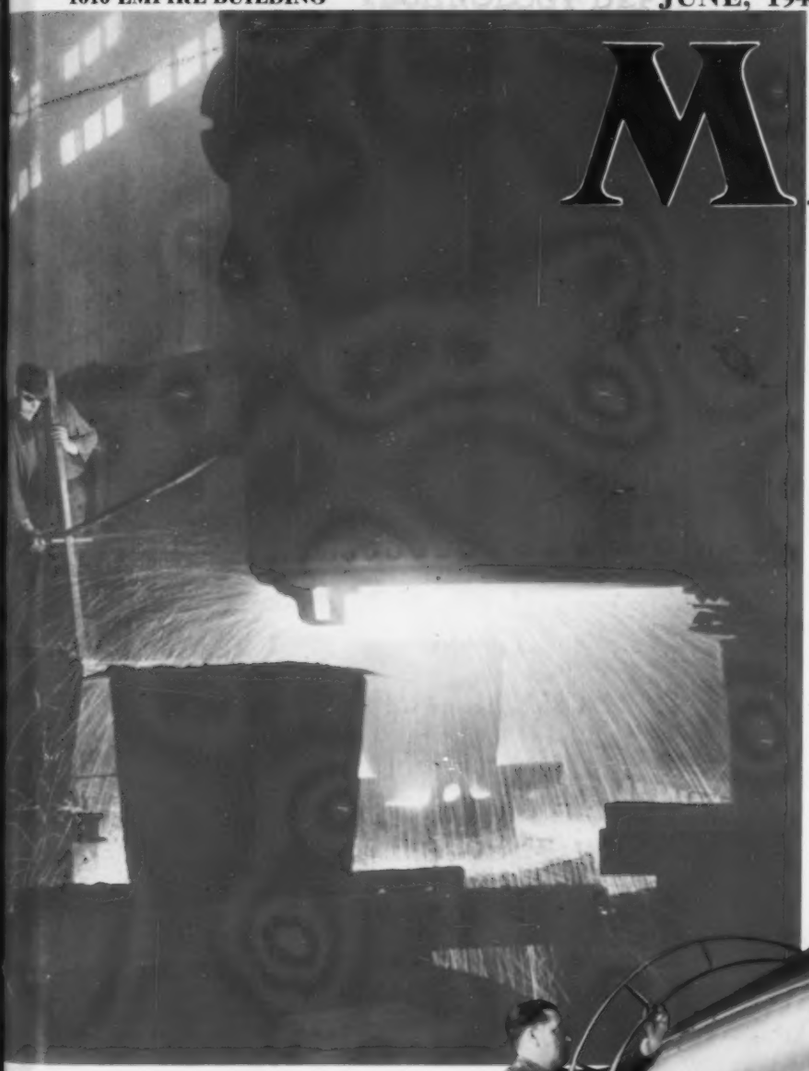
Iron and Steel ENGINEER

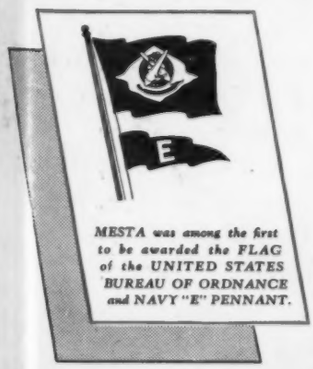
ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

1010 EMPIRE BUILDING — JUNE, 1942 — PITTSBURGH, PA.



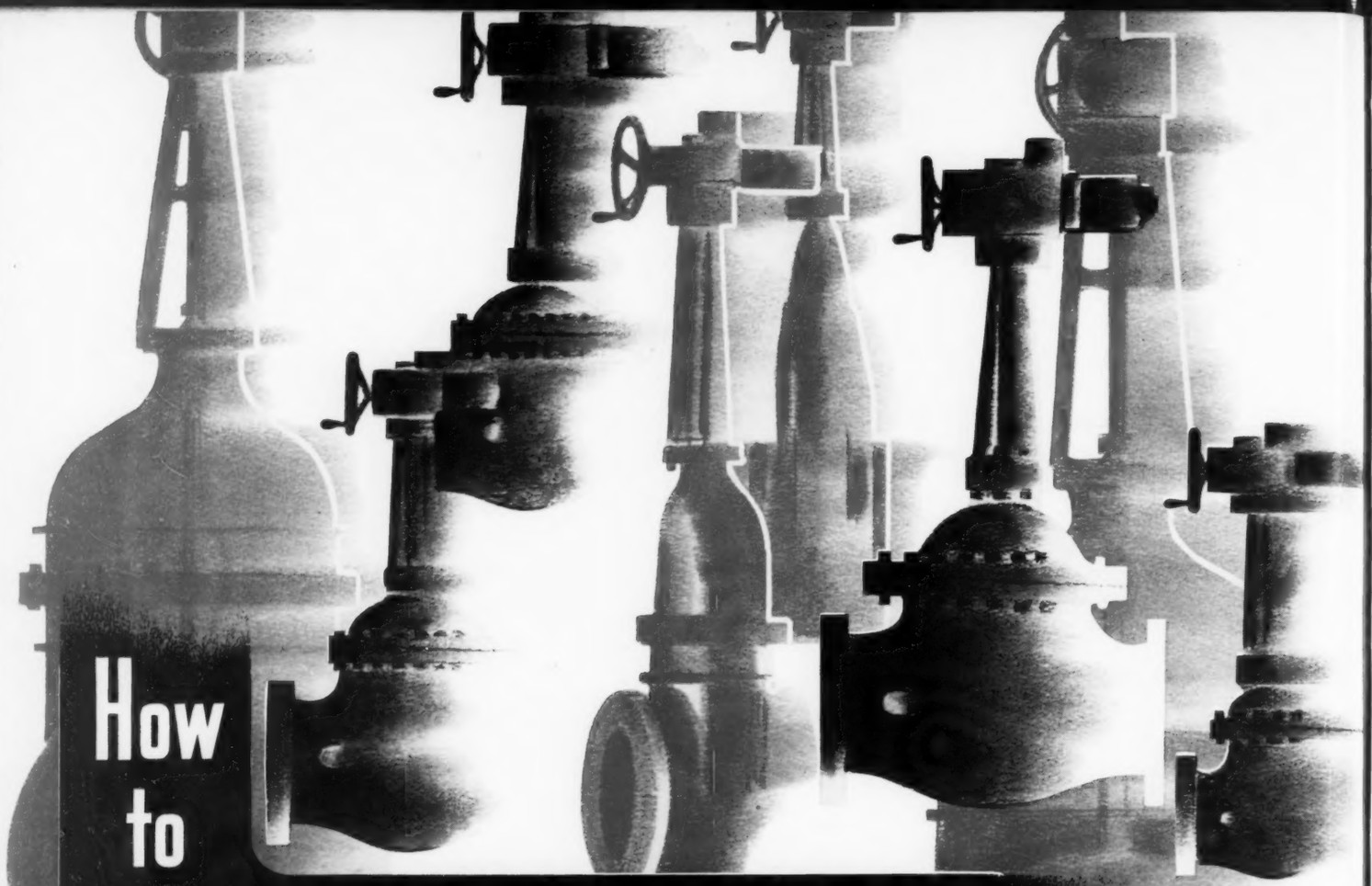
MESTA

SPECIAL ALLOY CAST STEEL BACKING-UP ROLLS FOR FOUR HIGH HOT AND COLD STRIP MILLS



MESTA was among the first to be awarded the FLAG of the UNITED STATES BUREAU OF ORDNANCE and NAVY "E" PENNANT.

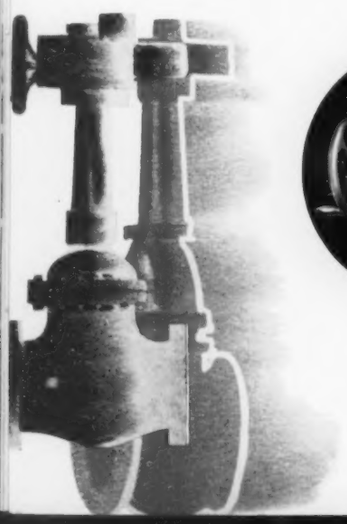
MESTA MACHINE COMPANY · PITTSBURGH, PA.

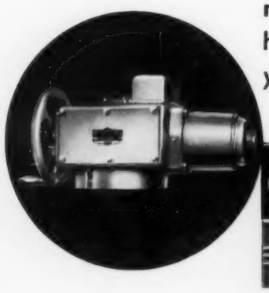


How to Seat all valves Properly

SO THEY WON'T BE DAMAGED BY TEMPERATURE CHANGES OR OBSTRUCTIONS

To seat all valves properly so that they are tightly closed yet safe, simply insist on Cutler-Hammer Motor-Operated Thrust-Seating Valve Control. It seats valves on a proven "controlled-thrust-seating" principle. That means *accurate* seating under normal conditions, and *safety* under abnormal conditions. But most important of all, C-H Thrust-Seating Valve Operators automatically maintain the same degree of tightness as valve parts expand under *high* temperature and contract under *low* temperature. That's why with C-H Valve Operating Units you never get jammed valves, you never have to "back-off" valves . . . *and you won't be faced with shutdown at a time when continued, trouble-free operation is at the highest premium in history.* Insist on Cutler-Hammer Valve Control. For gas, water, high and low pressure steam service—in fact for any valve where fast, reliable operation and accurate seating can save you time, trouble and expense. It offers you every feature—plus. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.





CUTLER-HAMMER
VALVE CONTROL
C-H

1892-1942 • 50th ANNIVERSARY

WB BRAKES, TOO, ARE Designed FOR CONVENIENCE

Rip-cord ring conveniently located for emergency use.

Compactly folded parachute carried in out-of-the-way position.

Parachutes provide utmost convenience for the airplane pilot—rip-cord ring *easily accessible* for emergency use—'chute in compact form, *located out-of-the-way,* frequently as seat or cushion for pilot.

Likewise, EC&M Type WB Brakes provide convenience not only for emergency operation but also for normal service. Manual release, a standard feature of these brakes, is valuable in making brake adjustments, replacing shoes, setting machinery—and, should power fail, it permits manual lowering of crane load.

Like the 'chute under the pilot, the connecting lever is below the brake wheel. An important feature, since it permits fast removal of motor-armature without dismantling the brake or disturbing any adjustments—makes shoe replacement easier, too.

Consider also, these other important features of the WB Brake: Liberal magnet design. Low contact-pressure per square inch. 50% of the wheel covered by brake shoes; 50% exposed to give heat radiation. Bulletin 1004-C gives complete details. Write for your copy.

Convenient hand release on top—a standard feature of all EC&M Type WB Brakes.

Out-of-the-way, like pilot's parachute, operating mechanism is *below* brake wheel.

THE ELECTRIC CONTROLLER & MFG. CO. CLEVELAND, OHIO

THE ELECTRIC CONTROLLER & MFG. CO. 2700 E. 79th Street CLEVELAND, OHIO

24 HOUR PRODUCTION

is no ordeal for LIMA-driven machine tools because they're protected with DOLPH'S

SYNTHITE No. 153-Y INSULATING VARNISH

Lima Electric's gearshift drives have been on a three-shift schedule for many months in gear hobber, drill, milling machine, shaper, borer, etc., applications. That these drives — functioning primarily in essential war production — are establishing an enviable reputation for efficient, dependable operation under exceptionally severe conditions, is due to excellent engineering and craftsmanship.

An important factor in the manufacture of Lima gearshift drives is Dolph's Synthite No. 153-Y Insulating Varnish. This hard, tough finish will not soften under heat, nor throw out due to centrifugal force on high speed armatures. Oilproof and water resistant, Synthite No. 153-Y is recommended for applications requiring good binding qualities and extreme rigidity.

AVAILABLE FOR ORDNANCE WORK

Dolph's Insulating Varnishes are obtainable during the emergency for vital work. As is the case with all other manufacturers, civilian needs must, of necessity, wait. However our chemists are available for collaboration on all varnish insulation problems now, whether in the production or planning stage. Your inquiries are invited.

HERE'S HOW TO PROLONG THE LIFE OF EQUIPMENT

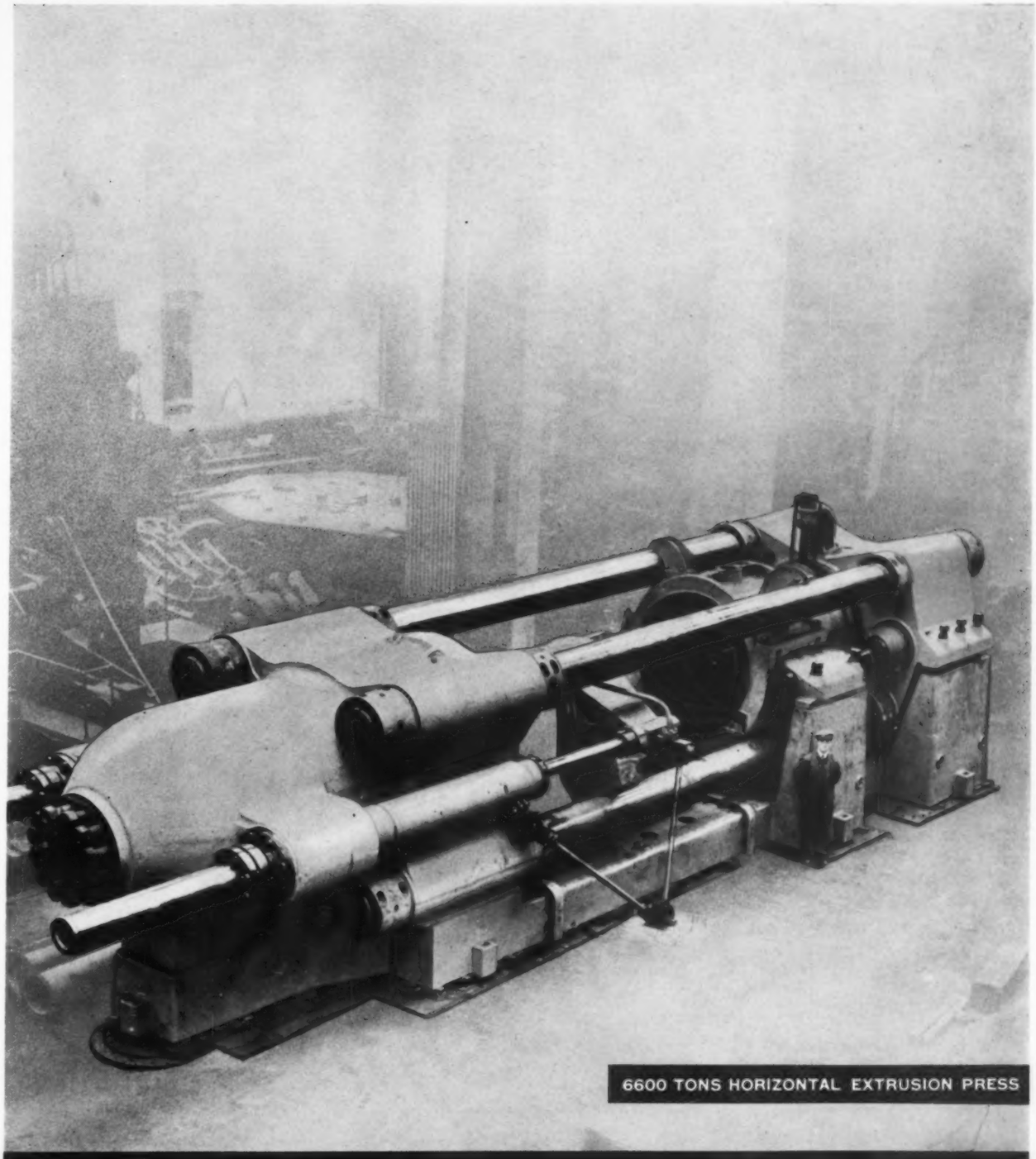
The correct insulating varnish can add years of trouble-free operation to your electrically-operated equipment. Burn-outs, usually caused by insulation failure, can be costly — today even irreplaceable. The new 40-page Handbook describes the complete Dolph line of insulating varnishes, their advantages and applications. Write today for your copy; there is no obligation. You will find it invaluable.

Dolph's

JOHN C. DOLPH COMPANY

Insulating Varnish Specialists

166-A EMMET STREET NEWARK, NEW JERSEY



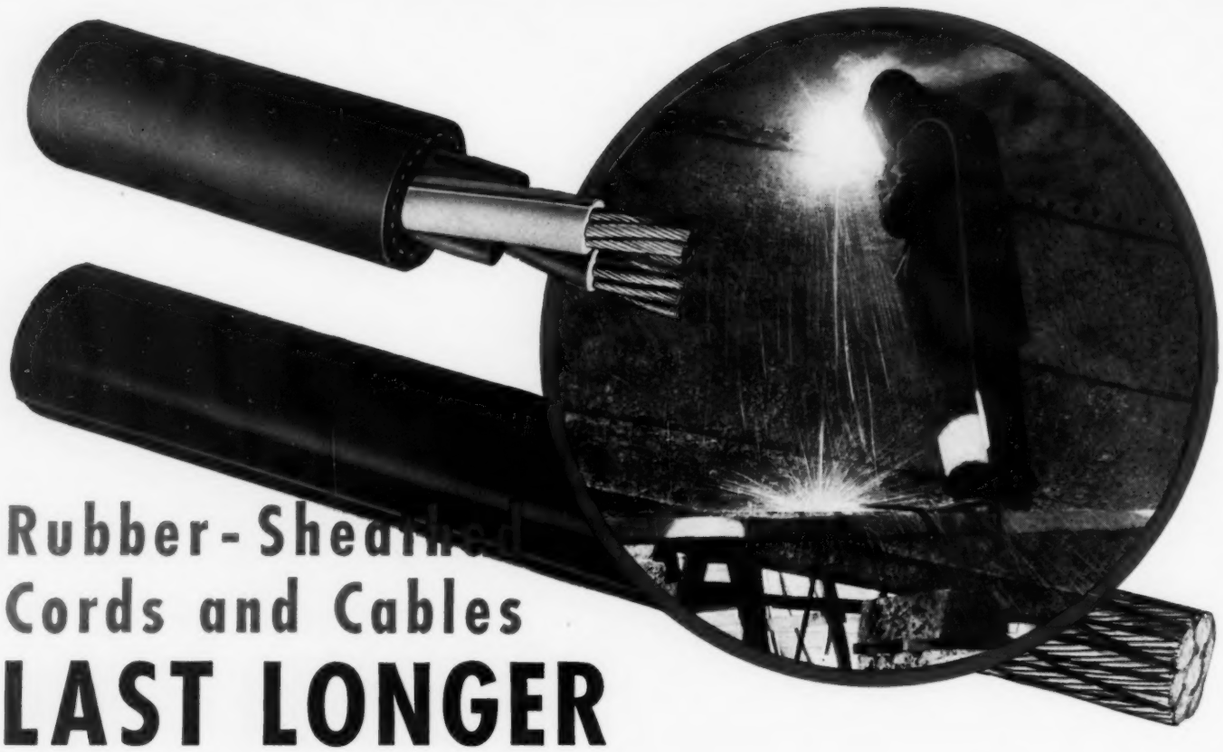
6600 TONS HORIZONTAL EXTRUSION PRESS

HYDROPRESS · INC.

ENGINEERS CONTRACTORS

HYDRAULIC PRESSES · ROLLING MILLS
PUMPS · ACCUMULATORS

570 LEXINGTON AVENUE · NEW YORK · N. Y.



Rubber-Sheathed Cords and Cables LAST LONGER

WHEN YOU . . . Wipe them regularly so they are free from oil, grease and chemicals. Such agents attack rubber and shorten its life.

WHEN YOU . . . Keep them out of light and sunshine as much as possible in use, and store them in a dark place. Light tends to harden rubber . . . thus hasten cracks.

WHEN YOU . . . Keep them away from steam lines, furnaces and hot objects as much as possible in use, and store them in a cool place. High temperatures shorten the life of rubber.

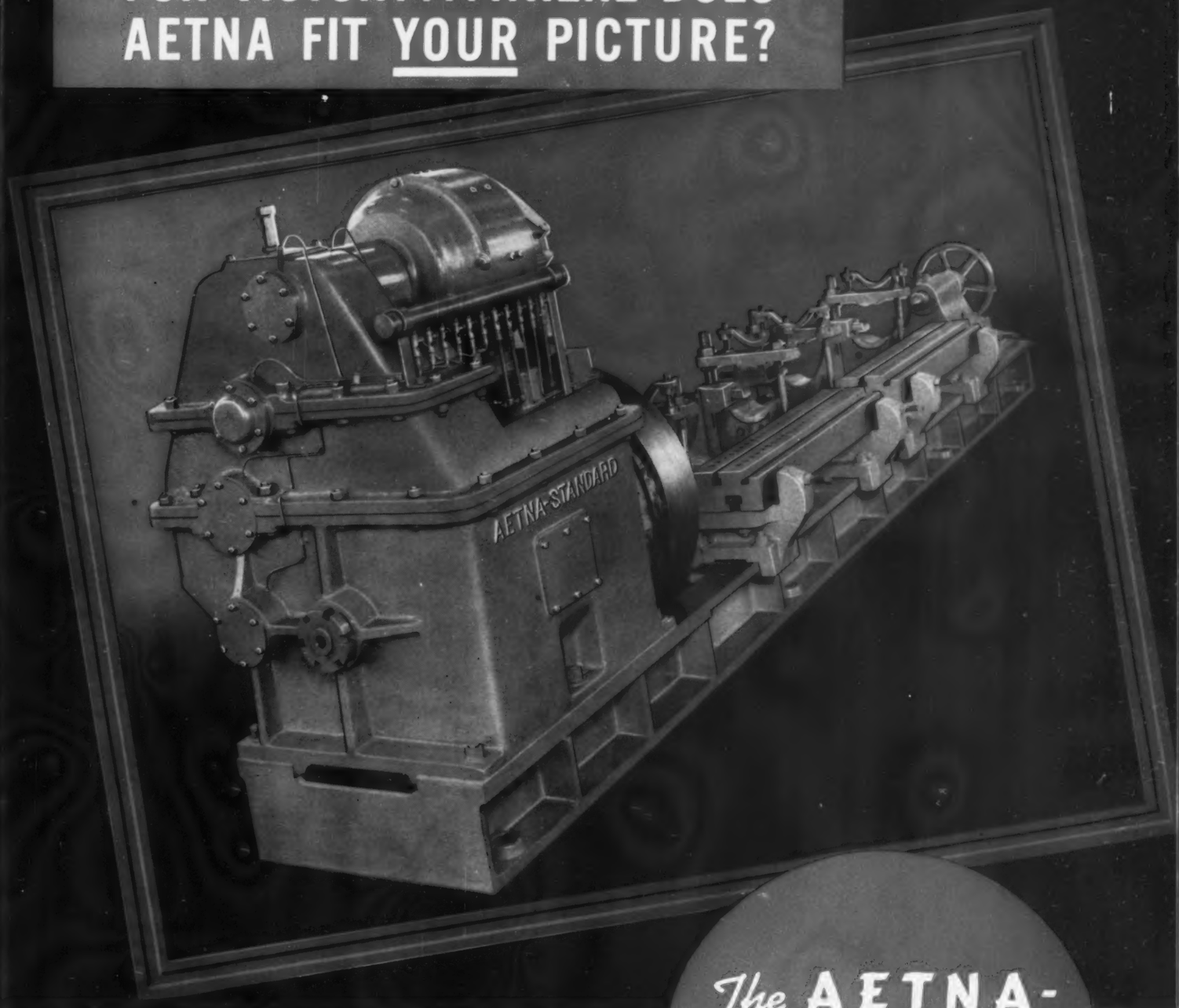
Even you who are using Okocord (water, acid, and alkali-proof) or Okoprene (oil and sun-proof) will get still longer service from these unusually durable cords by taking these simple precautions. Insulated wires and cables and all materials of which they are made are vital to war. Call on Okonite Engineers for help in installing, maintaining and operating them.

THE OKONITE COMPANY
Passaic, New Jersey
Offices in Principal Cities

OKONITE & MANSON
For perfect splices and terminals—use Okonite and Manson Tapes.

OKONITE
OKONITE
Insulated Wires & Cables

IN AMERICA'S PRODUCTION FOR VICTORY...WHERE DOES AETNA FIT YOUR PICTURE?



THIS AETNA heavy duty roll lathe is designed for turning alloy steel and chilled rolls, singly or in pairs. Will handle rolls of various lengths with diameters up to eighteen inches. Can be furnished with equipment for topping and necking including tail stock, removable neck bearings and face plate driver. Driven by a completely enclosed anti-friction gear drive with circulating oil system. A dependable piece of equipment that will give many years of economical service.

The AETNA-STANDARD ENGINEERING COMPANY

GENERAL OFFICES

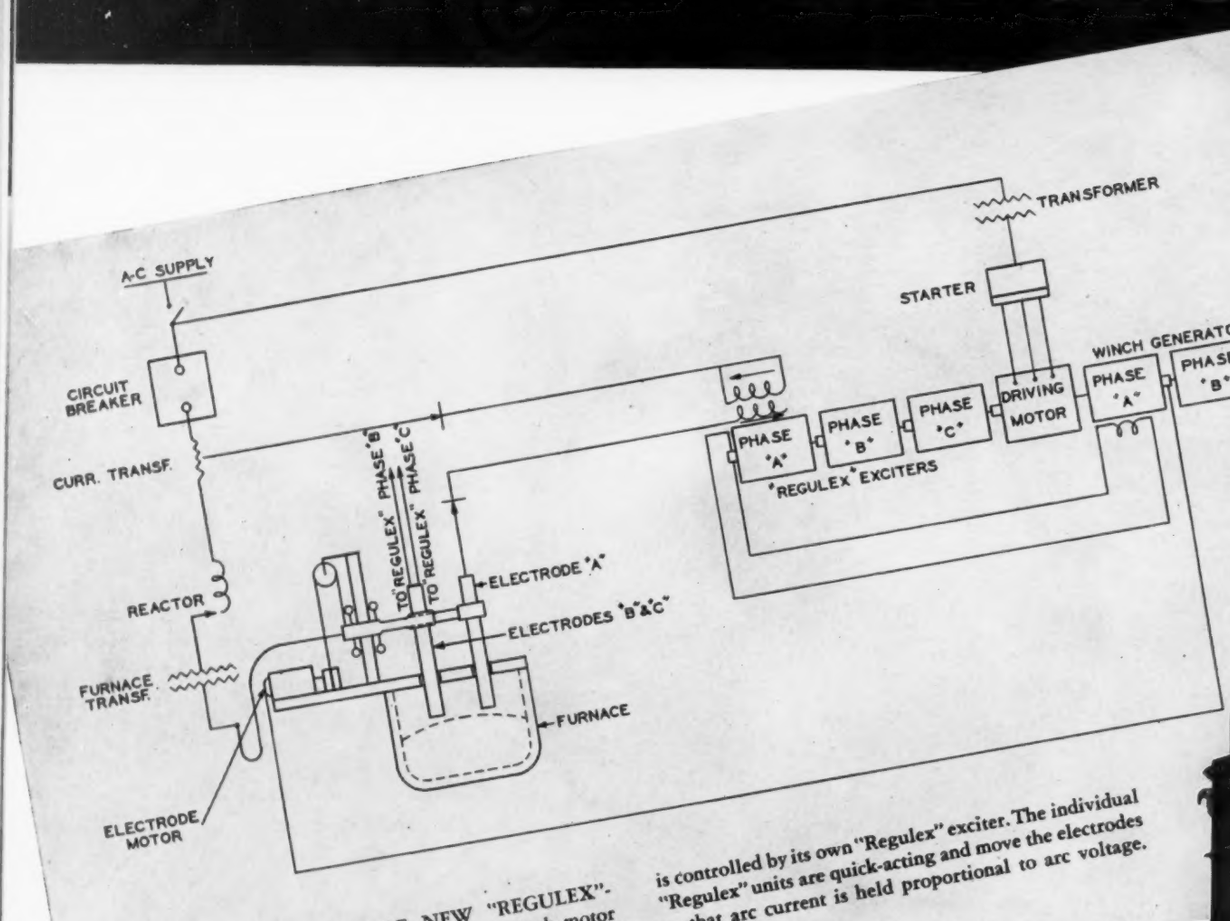
YOUNGSTOWN, OHIO, U.S.A.

ASSOCIATED COMPANIES

HEAD WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND •
JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

Designers and Builders to the Steel, Non-ferrous and Chemical Industries

Announcing..a
NEW ELECTRIC FU



SCHEMATIC DIAGRAM OF NEW "REGULEX"-controlled electric furnace. Each electrode winch motor is powered by an individual winch generator, which in turn is controlled by its own "Regulex" exciter. The individual "Regulex" units are quick-acting and move the electrodes so that arc current is held proportional to arc voltage.

PART OF THE COMPLETE ALLIS-CHALMERS INstallation — a 3000 kva indoor furnace transformer. Undivided responsibility pays a dividend because there's no "buckpassing".

Hold El
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Smooth

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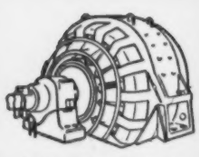
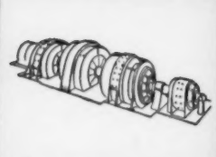
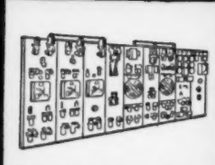
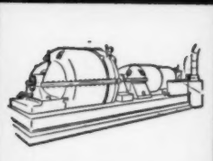
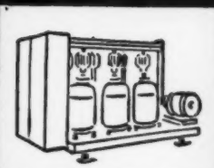
Get "All Out" production with ALLIS-CHALMERS


Main Drive Motors


Motor Generator Sets


Switchboards & Control


Blast Furnace Blowers


Mercury Arc Rectifiers

. . . a Revolutionary . . . FURNACE CONTROL!

Hold Electric Furnace Power Supply Stable . . . Increase Electrode Life . . . with Smooth, Fast-acting "Regulex" Control!

Here's an announcement electric arc furnace operators have long been waiting for . . . a smooth, fast-acting, contactorless control that holds arc current proportional to arc voltage!

Allis-Chalmers offers the "Regulex" exciter . . . already a favorite for its accurate, sensitive control on temper pass and reversing mills . . . for furnace electrode control. And six big engineering advantages show you how well "Regulex" control does this new job . . .

1. Since the "Regulex" exciter produces electrode speeds proportional to deviation of the controlled quantity from the desired value, sudden wide current fluctuations are compensated for rapidly, yet control is stable.

2. No large resistance is needed in the circuit — maximum rated speed of the electrode motor is available for automatic correction in case of a "cave-in." Electrode burning is held to a minimum.

3. All contacts and motor line contactors have been eliminated. Your servicemen don't have to waste their time on these chronic trouble-makers.

4. Arc furnace power and control are independent of d-c shop supply interruptions. Separate source means fewer furnace shutdowns . . . increased production.

5. Heavy starting surges, caused by throwing the 250 volt d-c motor across-the-line, are done away with by variable voltage control. Also, torque is applied gradually to the electrode rope system, minimizing effect of rope stretch.

6. Regenerative braking action of the "Regulex" unit stops electrode motors fast . . . prevents overshooting.

So pleased were the operators of one "Regulex" exciter-controlled furnace that, after only a short period of operation, they ordered eight more complete units.

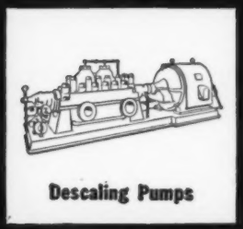
For complete information, call the district office near you. Or write direct to Allis-Chalmers, Milwaukee, Wisconsin.

A 1531

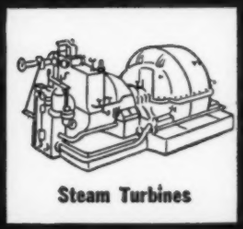
TAPPING A HEAT OF PLAIN CARBON STEEL FROM A MODERN electric furnace. Because the "Regulex" exciters respond quickly to sudden fluctuations in arc current, electrode burning is cut.

COOPERATIVE ENGINEERING

ALLIS-CHALMERS A-C MILWAUKEE



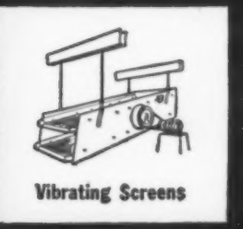
Descaling Pumps



Steam Turbines

Unit Substations

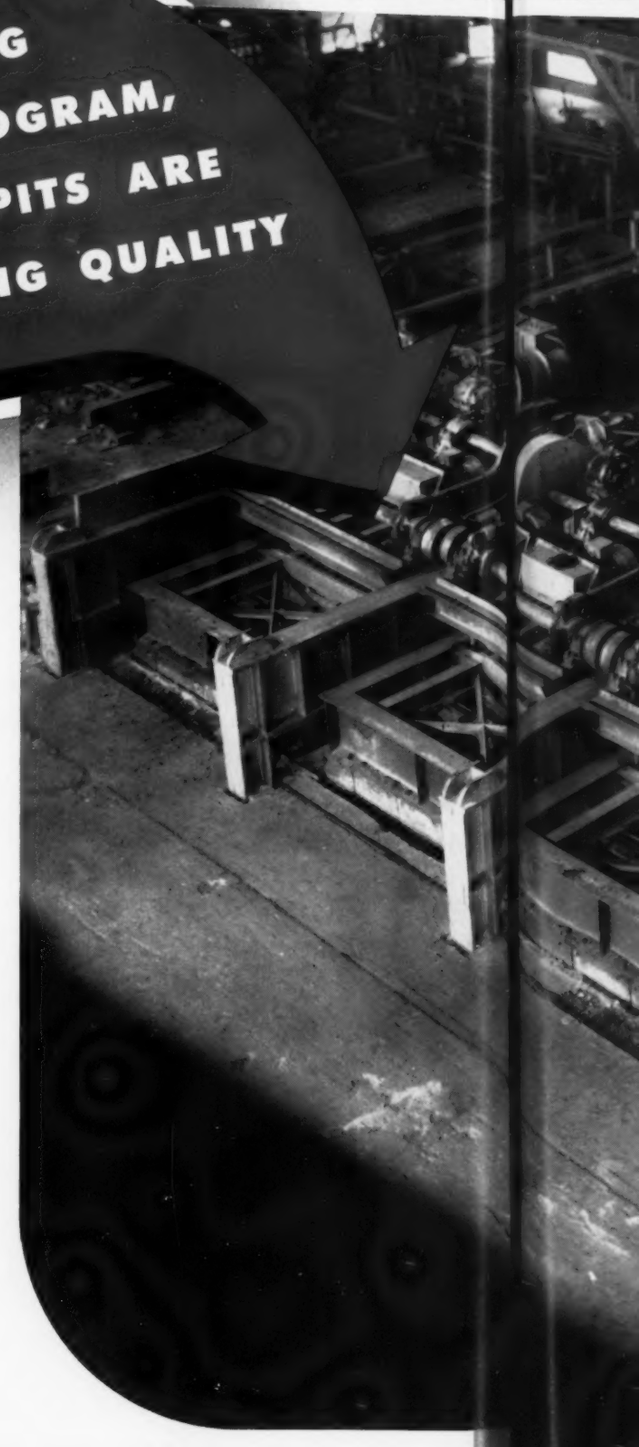
Gyratory & Jaw Crushers



Vibrating Screens

"MORE AND BETTER A

That's THE EVER INCREASING DEMAND OF THE VICTORY PROGRAM, AND SC ONE-WAY FIRED PITS ARE INCREASING YIELD, IMPROVING QUALITY



● STEEL, everyone realizes, is the basic metal upon which our ultimate victory depends. Every weapon of modern warfare except aircraft is made of 90% steel. The need for more and better alloy steels becomes a paramount production problem.

There is, within each organization in the steel industry, a constant urge to improve production, to raise the standards of quality, to improve yield, to lower operating cost. There is the ceaseless pressure of war production which drives the industry on toward the seeking of new and better methods and equipment.

Many companies are looking to their soaking pits for improvement. Old style pits are being replaced by modern SC one-way pits because . . . first cost is less; they are more economical to operate; they provide greater ingot capacity within existing buildings; provide more convenient arrangements and require less floor space, make possible uniform heating and easier control of pit operation, reduce scale losses and are fully automatic.

Most pits now in use can easily be replaced by up-to-date one-way fired pits, increase pit capacities with more economical operation. Designs are available for coke oven gas, producer gas, oil, blast furnace gas, natural gas or a combination of these fuels. SC engineers will gladly assist in laying out plans for improving quality and increasing yield of more and better alloy steels.

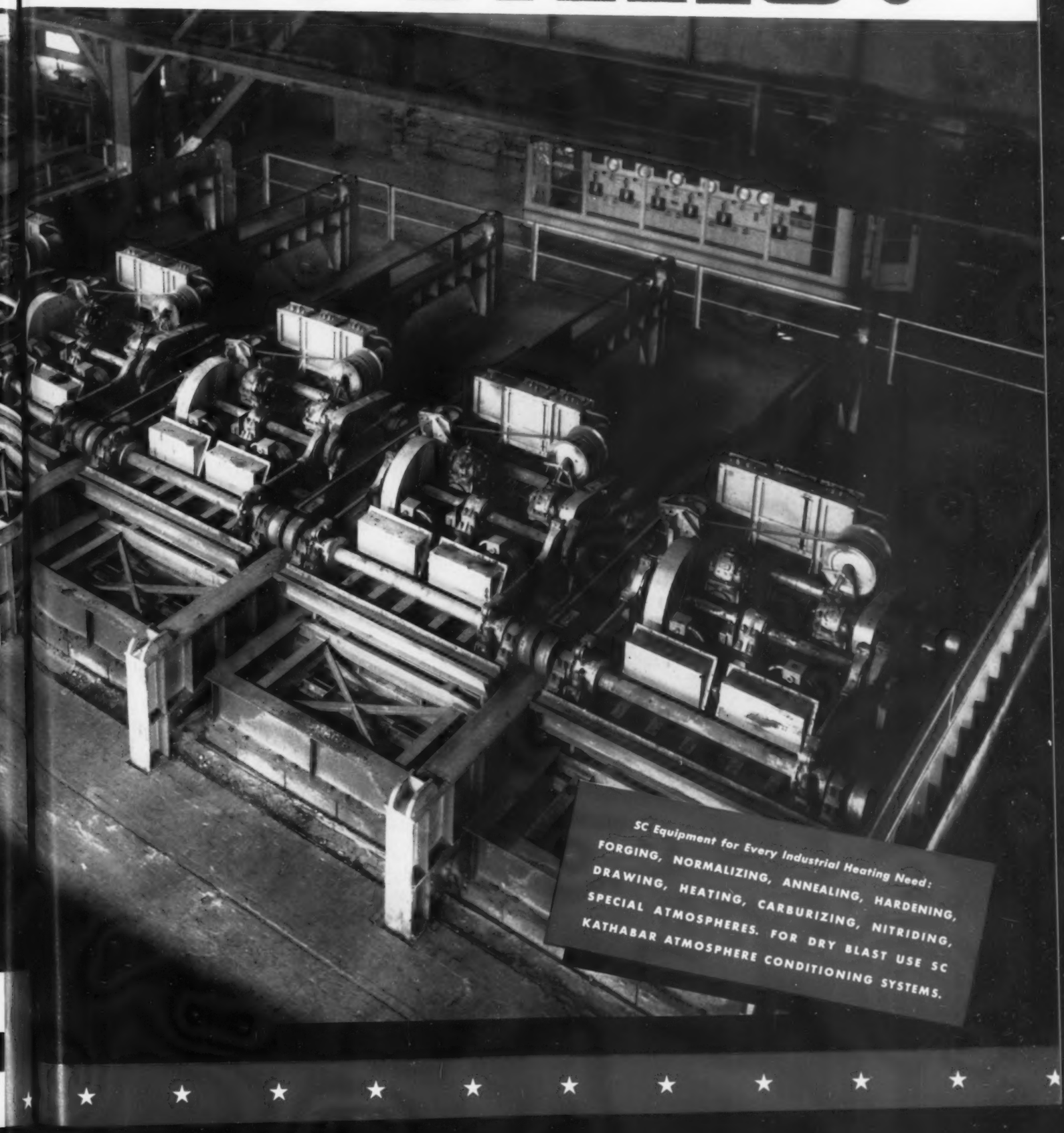
SURFACE COMBUSTION • TOLEDO, OHIO

★ SECURITY FOR AMERICA ★

SURFACE SC COMBUSTION

MANUFACTURERS OF INDUSTRIAL FURNACES · JANITROL GAS FIRED SPACE HEATING EQUIPMENT · AND KATHABAR AIR CONDITIONING SYSTEMS

ALLOY STEELS!"



SC Equipment for Every Industrial Heating Need:
FORGING, NORMALIZING, ANNEALING, HARDENING,
DRAWING, HEATING, CARBURIZING, NITRIDING,
SPECIAL ATMOSPHERES. FOR DRY BLAST USE SC
KATHABAR ATMOSPHERE CONDITIONING SYSTEMS.

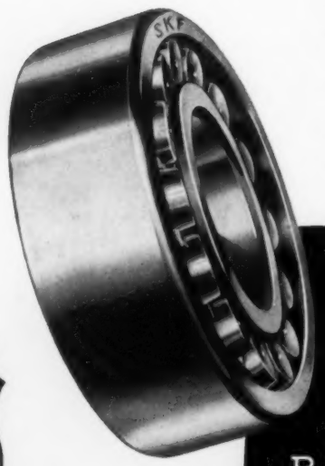
• *Built by* MESTA MACHINE CO.

Rolling 3750 FPM ...with SKF Bearings

Rolling tin plate at 3750 feet per minute in the world's fastest tin plate mill is not a job to be jeopardized by bearing trouble. So Mesta engineers, in designing this mill, specified self-aligning, self-contained bearings that have high thrust capacity. Not only do long-lived SKF Spherical Roller Bearings sustain heavy thrust loads while stabilizing the back-up rolls, but they compensate for misalignments without bearing binding. They're on the machines that keep production UP—always.

5074

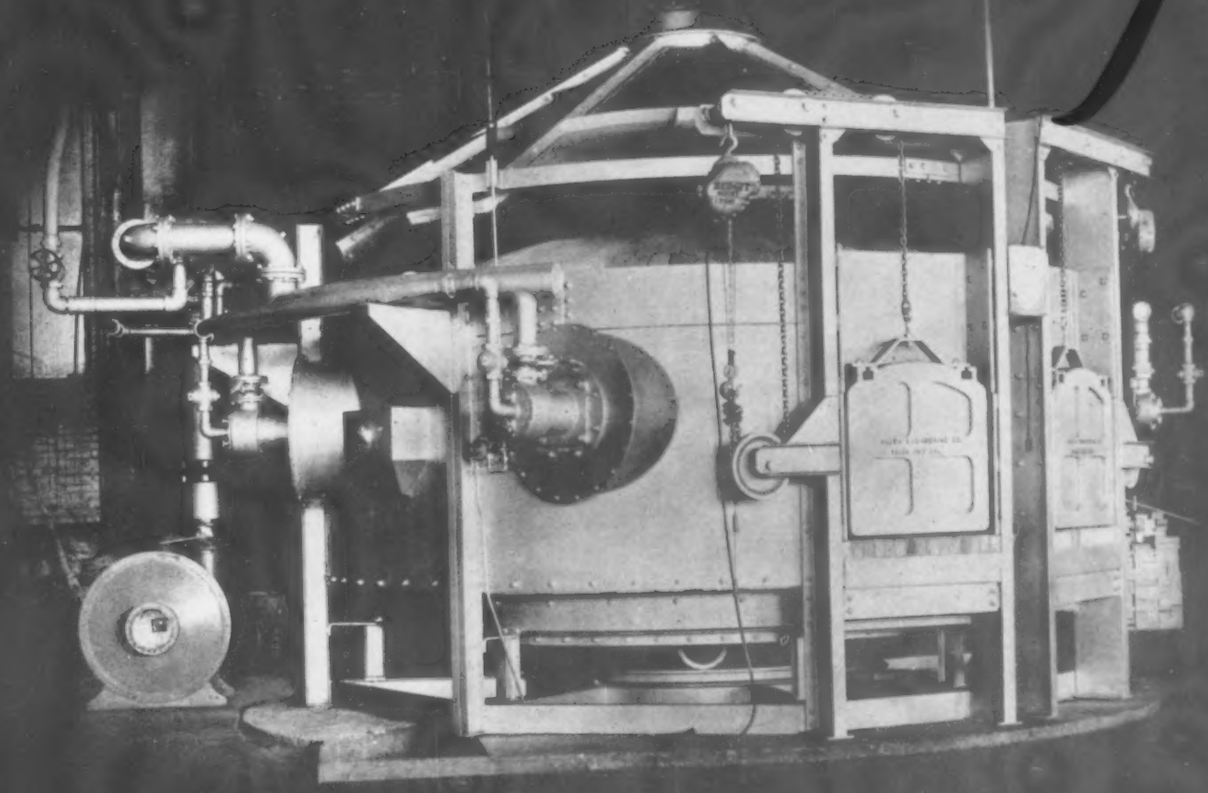
SKF INDUSTRIES, INC., FRONT ST. & ERIE AVE., PHILA.



SKF

BALL AND ROLLER BEARINGS

MORE SHELLS FOR *Victory*

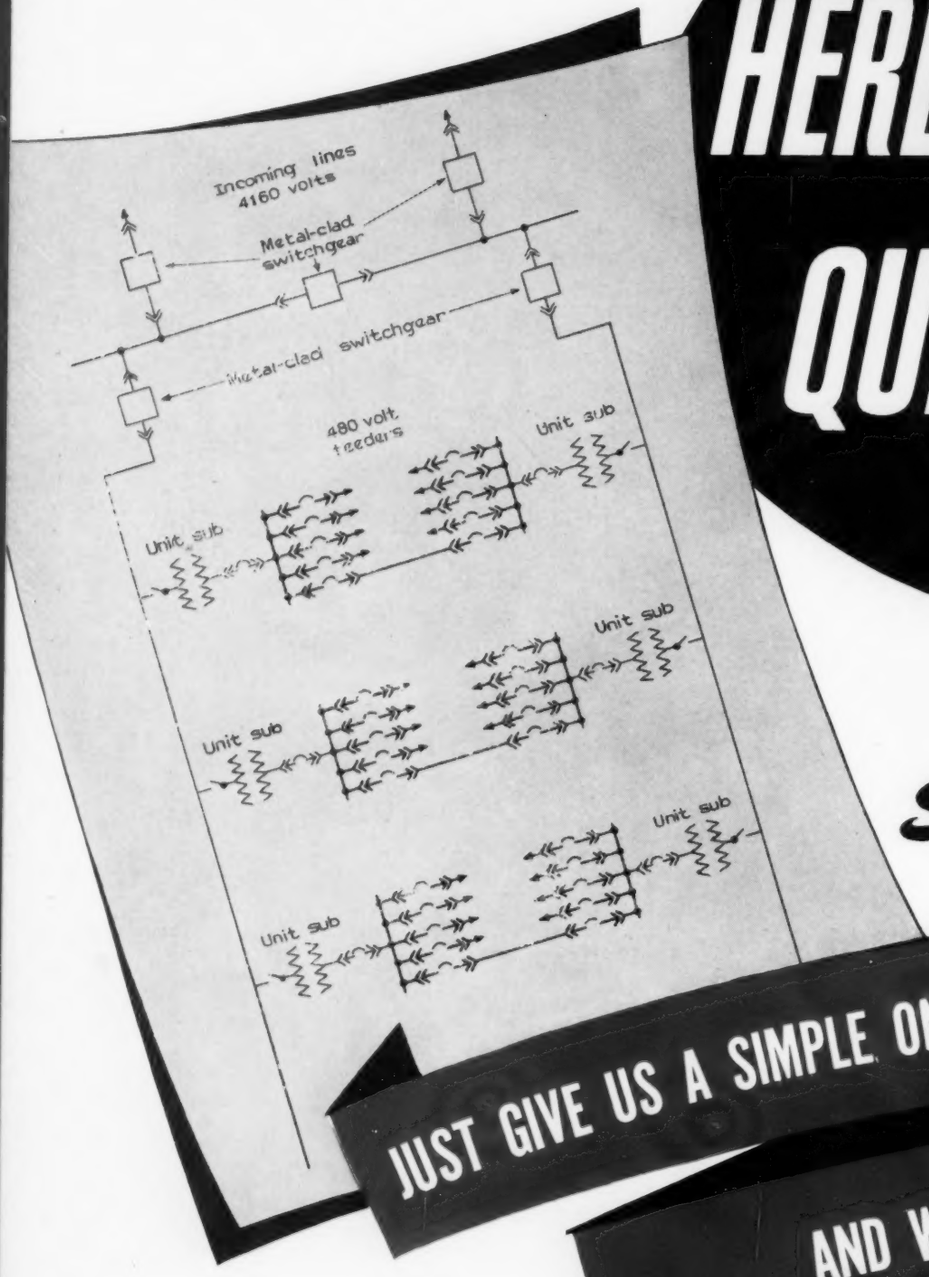


This Rotary Hearth Furnace heats 75mm billets for forging by the Witter Shell Process at the rate of one hundred and fifty 31 pound billets per hour. And the actual floor space required for this furnace is only 265 square feet!

SALEM ENGINEERING CO., SALEM, OHIO

SALEM ENGINEERING COMPANY

HERE'S A NEW QUICK WAY



TO GET SWITCHGEAR

JUST GIVE US A SIMPLE ONE-LINE DIAGRAM

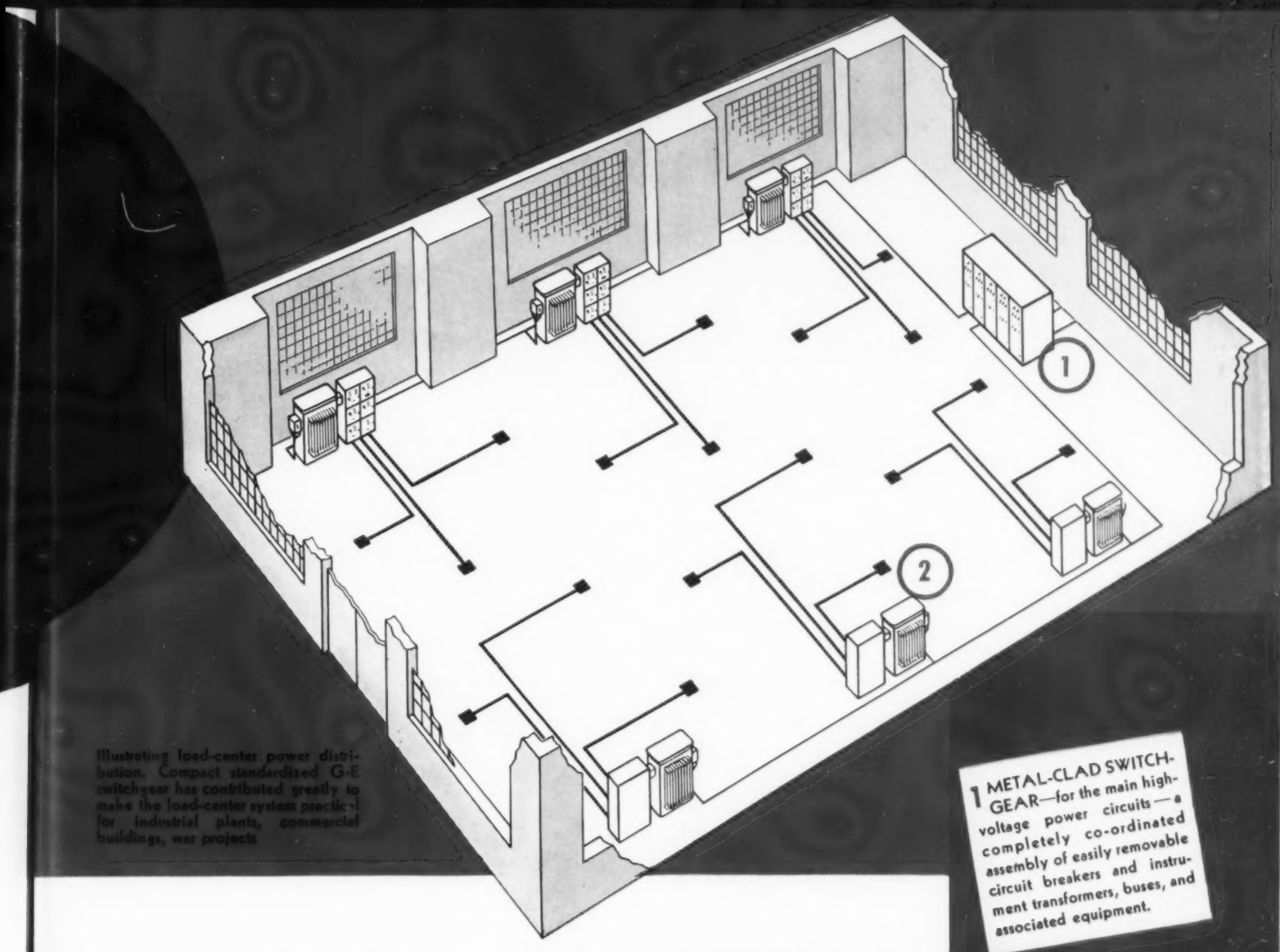
..... AND WE'LL GO TO WORK ON

STANDARD SWITCHGEAR equipments mean *more* and *better* switchgear for scores of plant engineers charged with equipping new and enlarged plants for wartime production.

More — because our own war-geared factories are tooled to make standard switchgear in ever-increasing volume. This means you'll get standard switchgear sooner.

Better — because we've worked for years to standardize the best equipments. We established a "one best" standard in every line—designed it for superior service over a wide range of applications. In recent years, industry ordered thousands of these "packaged" units to gain added safety, operating dependability and economy. Now the speedy production of switchgear, as well as quick installation, is so vital that standard switchgear is an ***absolute necessity***. And we're ready, with standard equipments already developed and proved.

General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance.



Illustrating load-center power distribution. Compact standardized G-E switchgear has contributed greatly to make the load-center system practical for industrial plants, commercial buildings, war projects

1 METAL-CLAD SWITCHGEAR—for the main high-voltage power circuits—a completely co-ordinated assembly of easily removable circuit breakers and instrument transformers, buses, and associated equipment.

2 LOAD-CENTER UNIT SUBSTATIONS—for distribution, control, and protection of low-voltage power up to 600 volts—a completely co-ordinated assembly of drawout-air-breaker switchgear equipments, transformers, and high-voltage protective devices.

EVERYTHING IN STATION SWITCHGEAR, TOO—Complete switchgear for the power station is described in our new bulletin, GEA-3742 — everything from large FH cubicles right down to the metal-enclosed bus runs.

Standard EQUIPMENTS

Get Any or All of Your Plant Switchgear Equipments This Easy Better Way

NOW you can save precious days and weeks formerly spent over the drawing board and in drawn-out correspondence. Now you need only give us a simple one-line diagram showing the switchgear functions to be performed and the ratings.

You'll get our standard switchgear—the best, and the safest, we know how to build.

You can get everything you need in plant switchgear this quick, simple way. Every one of our standard equipments is designed for the broadest possible application. Our line of standard equipments is complete. Ask your nearest G-E office for additional information, or write the General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC

B54-16-7300

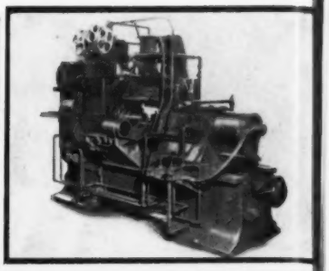
WEAN

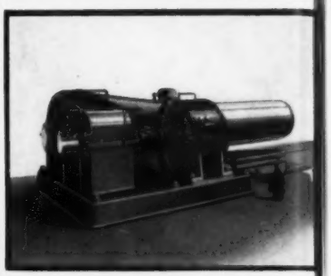
STEEL MILL *Equipment*

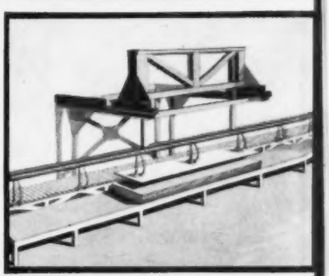
PRODUCTS•

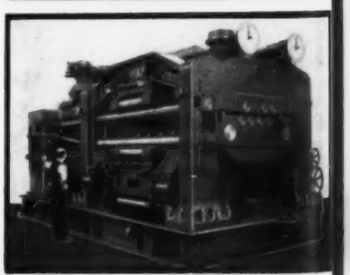
Continuous Strip Coiling Equipment.
Special Conveying Mechanism.
Automatic Pilers.
Uncoiling Units.
Press Feeding Equipment.
Slitters.
Strip Uncoiling and Automatic Shearing Units.
Strip Coil Holders.
Strip Coiling Reels.
Sheet Galvanizing Equipment.
Automatic Tinning Equipment.
Automatic Doublers.
Normalizing Furnaces.
McKay Levellers and Processing Units.
Strip Welding Equipment.
Continuous Strip Pickling Equipment including: Uncoilers, Up-Cut Shears, Stitching Machines, Pinch Roll Units, Recoilers, Drying Machines, Pickling Tanks, and Auxiliary Equipment.
Scrubbing, Leveling and Oiling Machines for Flat Products.
Wilson Vertical Tube Type Annealing Furnaces.
Corrugated Inner Covers.
Automatic Feeding and Catching Tables.
Continuous Pack and Pair Heating Furnaces.
Wheelabrator Abrasive Cleaning Equipment.
Automatic Weight Classifier.
Automatic Gauge Classifier.
Shell Lathes.
Airplane Motor Sleeve Lathes.
Armor Plate Levellers.
Vacuum Cup Lifters.

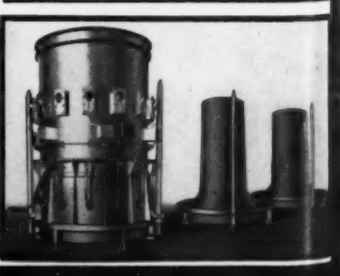
For WAR Purposes











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"GIVE ME MOLONEY POWER TRANSFORMERS FOR LOWER MAINTENANCE COSTS"

CHECK THESE FEATURES

Moloney cylindrical blowers are of the same type as used on air conditioning systems. They are extremely quiet and efficient in operation. They are automatically controlled by either oil or hot spot temperature.

Moloney radiators are of all welded construction. Tubes are spaced for easy cleaning and painting. All welds are external. Headers are designed so water cannot stand on surface.

Moloney tanks are sturdily constructed. Tanks walls are adequately reinforced with husky Z bars or strong welded box-type ribbing. Bases are of heavy welded channel iron construction.

13,333 KVA, 3-PHASE, 33,000 PRIMARY TO 4500Y SECONDARY

"For example, just look at this transformer. Notice the radiator construction. There's no place where water can collect and cause rust. Those radiators are easy to clean and paint; the tubes are not crowded together."

"That tank never will give us any trouble. It's strongly built; heavily reinforced where it is necessary."

"Those blowers are driven by weatherproof motors equipped with self-lubricated ball-bearings. They require practically no attention at all; and notice how quietly and smoothly they operate."

Electrically, as well as mechanically, Moloney Power Transformers are well made and require a minimum of maintenance. Send for a copy of Bulletin PR391103 describing other Moloney features and showing Moloney Power Transformer installations.

MOLONEY ELECTRIC COMPANY • ST. LOUIS, U.S.A.

POWER AND DISTRIBUTION TRANSFORMERS EXCLUSIVELY SINCE 1896

TROUBLE-FREE SERVICE
ON A BIG, ROUGH, TOUGH JOB . . .

An Alliance Charging Machine in one of America's Large Steel Plants

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FORGING MANIPULATORS
SOAKING PIT CRANES, STRIPPER CRANES
SLAB AND BILLET CHARGING MACHINES
OPEN HEARTH CHARGING MACHINES

Alliance

The charging machine, illustrated above, is a good example of Alliance heavy duty equipment. Having been designed and built ruggedly by experienced engineers, this, and all Alliance equipment, meets production demands accurately. . . . Furthermore, Alliance machines and cranes permit long hours of continuous operation without delay for maintenance or repair. **Our engineers realize that present day operating problems could not be conquered without incorporating plus-values into our equipment.*

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Hot and Cold Mills . . .

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The NEW Abramsen Straightener

Improved Johnston Patented Corrugated

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Heavy Duty Engine Lathes

With all the stands of your 4-high Hot and Cold Mills equipped with "Techni" Process back up rolls, you will get greater production, lower cost per rolled ton. These rolls are made of enriched true alloy steel. They are especially heat treated to produce the required hardness of the body surface, and are well tempered so as to toughen them to resist spalling and crumbling of the surface under pressure. The journals are soft and strong to withstand imposed stresses.

Since 1803—Pioneers, Engineers and Builders

MACKINTOSH-HEMPHILL COMPANY . . . . Pittsburgh and Midland, Pennsylvania

The Rolls with the Red Wabblers

They Roll More Tons Per Grind

"Techni"

PROCESS BACK UP ROLLS

have

greater strength

longer wear

freedom from spalling and internal defects

FIGHTING FACTS on the BILLETEER

1. Saves time. It speeds up billet-chipping as much as 90%.

2. Saves men. It is power operated through finger-tip control by ONE man.

3. Saves money. Average reduction in billet-chipping costs is 50%.

4. Saves steel. Many billets, of special alloy steel, that would otherwise be considered scrap, can be salvaged on a BILLETEER.

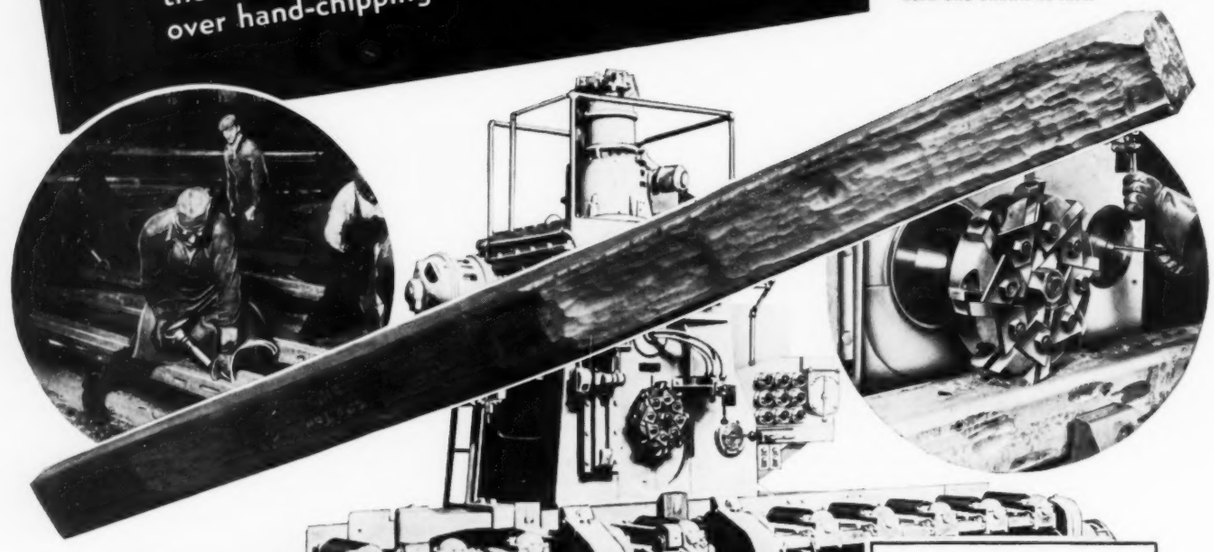
5. Efficient on steel of any analysis. The harder the steel and worse the defects— the greater the saving over hand-chipping.

VERY HIGH PRIORITY RATING IS GIVEN THIS EQUIPMENT.

DELIVERIES DEPEND ON HOW SOON YOU PLACE YOUR ORDER.

RESULTS COUNT!

On the billet shown below, light portion at right (5/6 of surface) was cleaned by Billeteer in 1/8 of time required to clean by hand the dark end shown at left.



The Billeteer cutting head with 8 or 10 tools makes fast work of seams and defects. It cuts away approximately 120 bites a minute.

BUILDERS OF BONNOT-LENTZ BILLETEERS ALSO CRUSHING PULVERIZING AND MIXING EQUIPMENT

THE Bonnot COMPANY

STEEL EQUIPMENT DIVISION

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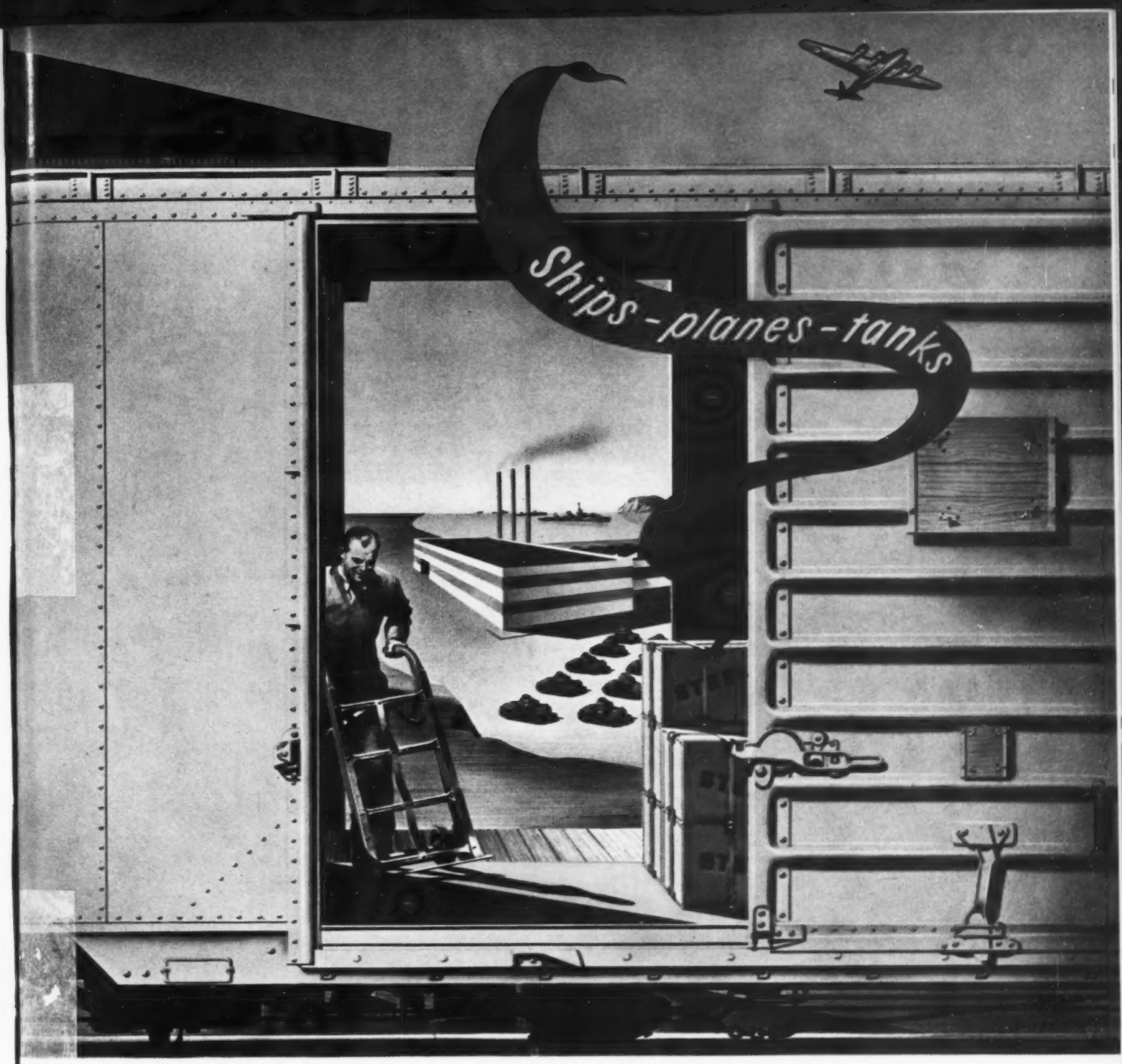


Even before they're made they must travel

American planes could never hope to dominate the skies . . . American tanks could never crash their way to victory . . . American ships could never hope to succor a desperate world . . . if American *transportation* had not first done the biggest job of its kind in history.

At a time when *everything* depends upon a free flow of traffic, the American transportation system has worked so magnificently that America, like a man with a good stomach, has scarcely been aware of its existence.

Even before ships, planes, tanks and guns are made, the railroads and other means of transportation must carry the raw materials thousands of miles from a thousand suppliers to a thousand different parts of the nation.

Koppers has been able to furnish supplies of basic materials needed by the transportation industries . . . from Koppers coal mines, from Koppers plants where ties and other wood products are pressure-treated to give them long life, from Koppers creosote refineries, from Koppers roofing and waterproofing plants, and paint factories . . . from plants which make packing for steam locomotives and piston rings for Diesels.

Maybe, some day in the future, these products may serve your peacetime operations as they are now serving wartime safety. Koppers Co., Pittsburgh, Pa.

KOPPERS

THE INDUSTRY THAT SERVES ALL INDUSTRY

BUY UNITED STATES WAR BONDS AND STAMPS

FARREL DRIVES for VICTORY UNDER the NAVY "E"

The Navy "E" lapel emblem awarded to all Farrel-Birmingham employees

In recognition of *Excellence* in the production of Farrel Gear Drives for Navy ships, our three plants at Ansonia and Derby, Conn., and Buffalo, N. Y., have been awarded the "E," traditional Navy symbol for a job "Well Done."

In all our plants resourceful engineering, skilled workmanship and modern facilities are being combined in a sustained drive not only to meet but continuously to exceed the Navy's expectations in production performance, so that we may more than merit this distinctive honor and keep the "E" burgee flying over our plants.

Every member of our organization is proud of the honor conferred upon him and all dedicate their individual and cooperative effort to the utmost production of war equipment needed for America's Victory Drive.

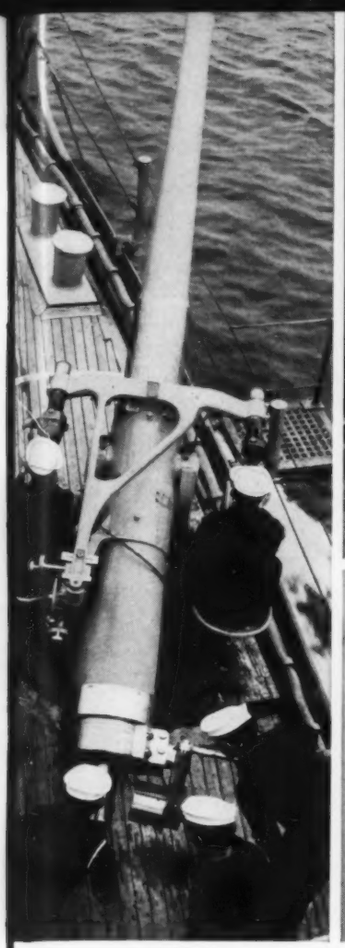
When victory is won this same combination of plant and personnel will again be able to devote its facilities and skill to building equipment for the advancement and improvement of manufacturing processes for American peacetime industry.

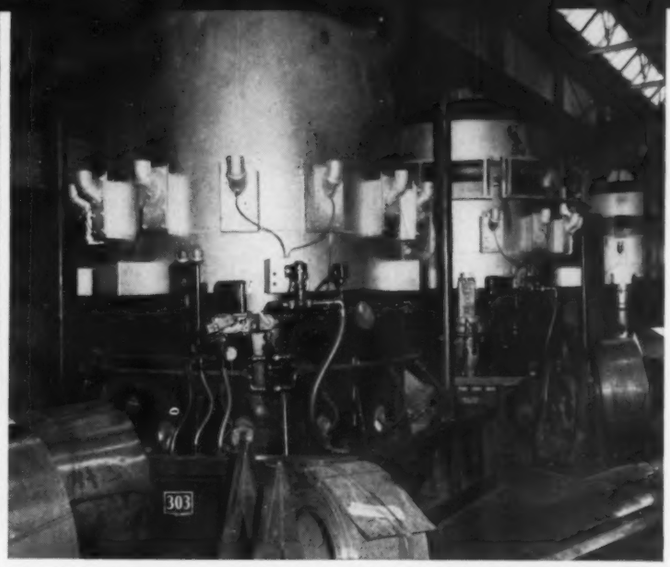
FARREL

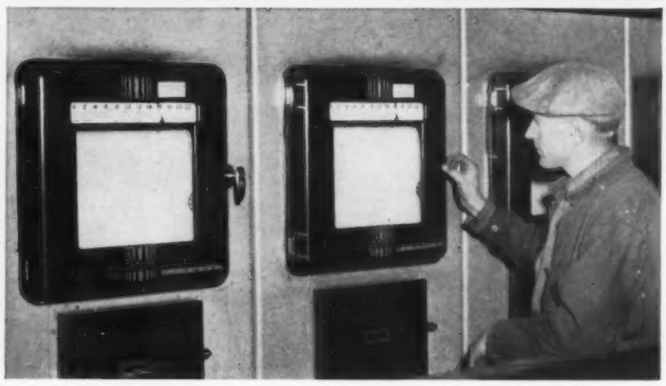
FARREL-BIRMINGHAM COMPANY, INC.

ANSONIA, CONN., BUFFALO, N. Y.

Plants: Ansonia and Derby, Conn.; Buffalo, N. Y.







Official U. S. Navy Photo

The handling of Industry's big furnaces, like the handling of big guns, is a job for trained men with fine instruments. Here are Micromax pyrometers, regulating the temperature of an Ohio steel mill's cover furnaces.

MICROMAX TURNS ON THE HEAT FOR MORE WAR-TIME STEEL

Annealing steel strip for use in guns, ships, tanks, etc., is the job of the battery of Micromax-controlled cover furnaces shown above. The furnaces are Wilson radiant-tube units, having a capacity of several tons each. Temperature is controlled by Micromax Thermocouple Pyrometers directing the action of fuel-valve drives. The instruments themselves are standard, but the details of their installation present some features of value for other instrument users.

The Pyrometers are in a Control Room, back against the building wall. They are out of the way of cranes, trucks and unauthorized fingers, and are also well away from the cover furnaces, which, of course, are moved about in the big annealing shop.

Furnaces have some couples embedded in the load; others near the tubes. Valve-drives are permanently mounted on the furnaces; one can be seen in the foreground.

The method for connecting furnaces to Micromax Controllers is to have long lead-wires from both couples and valve-drives, and from the instruments. By means of standard terminals, a furnace any place in the shop can then be "plugged in" to a Micromax Controller.

The controller may turn fuel up and down rather abruptly (on-and-off control) or it may throttle it gently (proportional-position-plus-floating control). The method used depends on the type of furnace, the load, the job to be done, and so on. It may go from one method of control to the other, and base its work on a thermocouple in the load, or on one outside. It may regulate rate of heating and cooling as well as soak temperature.

But, whatever its instructions, Micromax carries them out in *its own fully-automatic way.* Naturally, in a big steel mill, the operators don't just walk away and leave an acre of furnaces entirely to the automatic controls, but, as far as Micromax (Model S shown) is concerned, even this could be done for some days at a time.

For Micromax needs no daily attention. It standardizes itself, thus preserving its own accuracy. In 24-hour service, it needs ink every 2 weeks or so; chart perhaps once a month; oiling, cleaning and dry cells only at long intervals. Even if an operator wants to "baby" the pyrometer, there's very little he can do. The machine attends, micro-responsively, to its job of regulating temperature; records the results as it goes along; helps turn out steel which is perfectly annealed for America's growing war machine.

Micromax Controllers are available in 5 models, and most applications are, of course, far simpler than the one described above. Our engineers will be glad to help you select and apply the one to regulate any furnace in which you may interested.

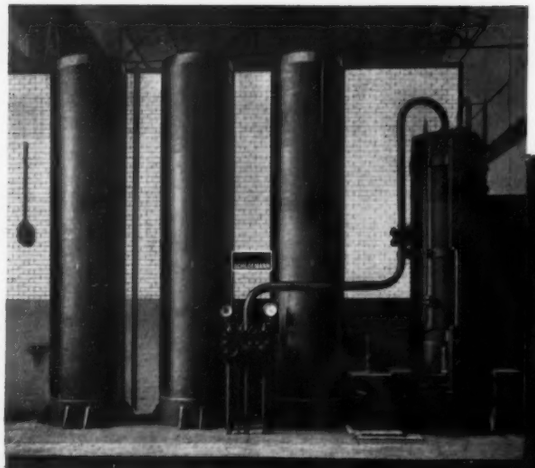
A G-E Catenary-type electric furnace, for normalizing steel strip, is controlled by this battery of Micromax Pyrometers in an Ohio steel mill. Heating chamber is 31 ft; cooling is 60 ft; power rating is 460 kw, 220 volts, 3 phase. A typical example of how Micromax is selected for the vital, big jobs of temperature control throughout the metal industries.

Jrl Ad ENT-0600C(48)

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

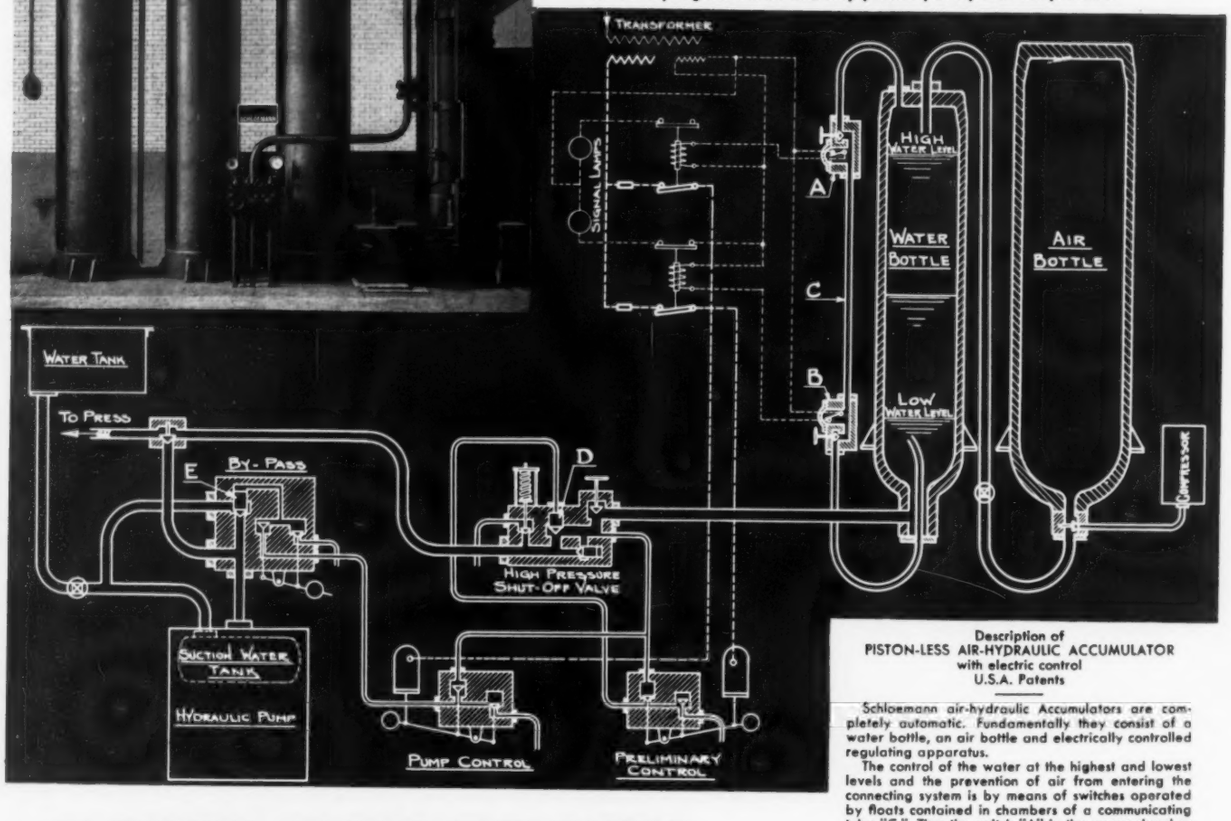
LEEDS & NORTHRUP

MEASURING INSTRUMENTS • TELEMETERS • AUTOMATIC CONTROLS • HEAT-TREATING FURNACES



Accumulators furnished in sizes from fifty gallons to twenty-five hundred gallons and for pressures up to forty-five hundred pounds per square inch.

System shown at left has two hundred gallons capacity and is designed for twenty-eight hundred and fifty pounds per square inch pressure.



Description of
PISTON-LESS AIR-HYDRAULIC ACCUMULATOR
with electric control
U.S.A. Patents

Schloemann air-hydraulic Accumulators are completely automatic. Fundamentally they consist of a water bottle, an air bottle and electrically controlled regulating apparatus.

The control of the water at the highest and lowest levels and the prevention of air from entering the connecting system is by means of switches operated by floats contained in chambers of a communicating tube "C." Thus the switch "A" in the upper chamber controls the operation of the hydraulic pump, while that in the lower chamber "B" controls the check valve "D" which shuts off the accumulator at lower water level.

The continuous running pump is controlled by closing the By-Pass check valve "E" by means of the pump control, causing it to idle by opening the same and returning the water to the suction end. Over-pressure is released through safety valves and is indicated by an alarm.

SCHLOEMANN

AIR-HYDRAULIC ACCUMULATORS

HYDRAULIC EXTRUSION PRESSES

HIGH PRESSURE PUMPS

COMPLETE HYDRAULIC SYSTEMS

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Rolling Mill Machinery Hydraulic Presses

For STEEL SHELL CASE *Annealing*

WILSON radiant tube fired continuous type furnace designs, with deoxidizing gas atmosphere and controlled cooling for bright annealing steel shell cases, are available.

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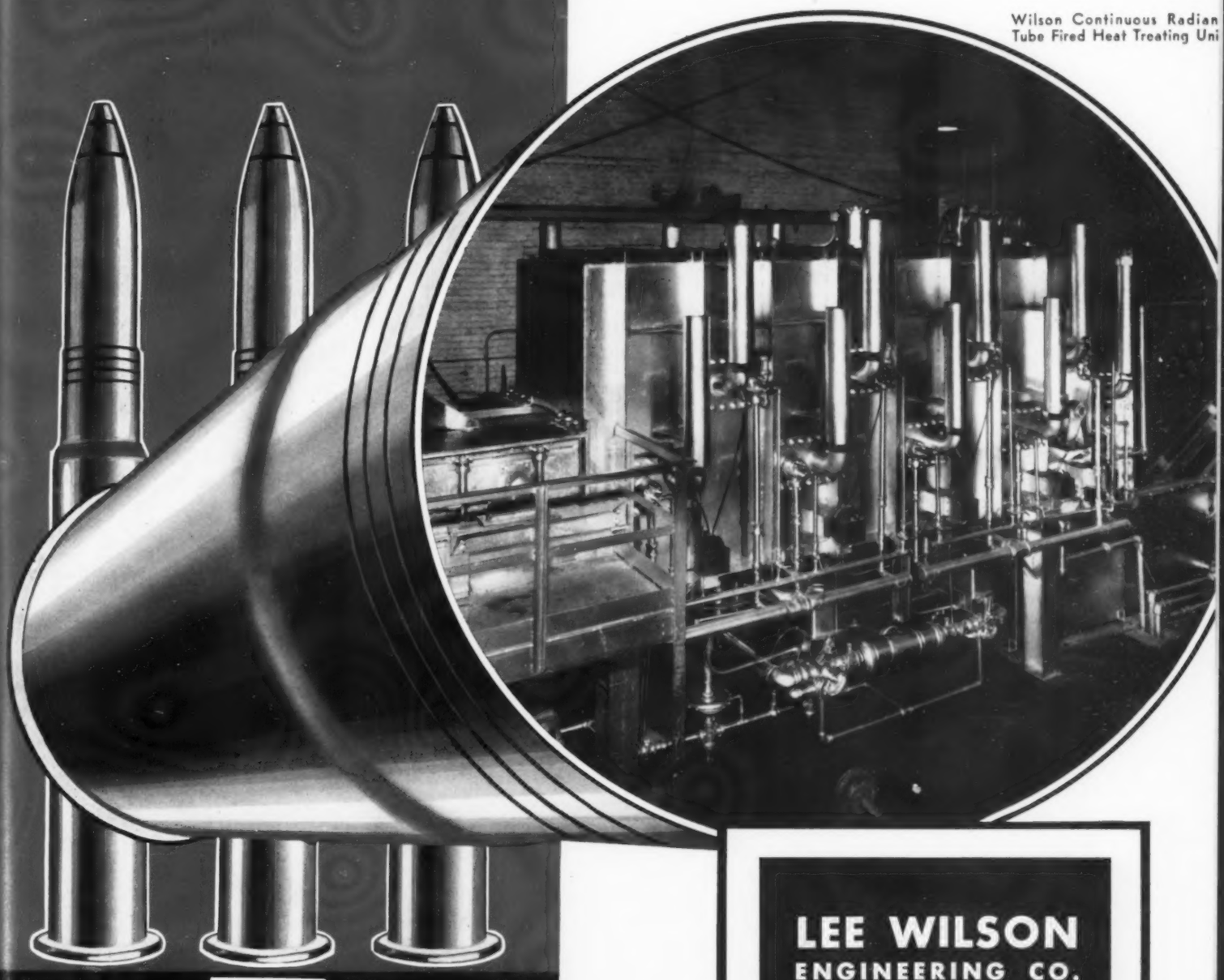
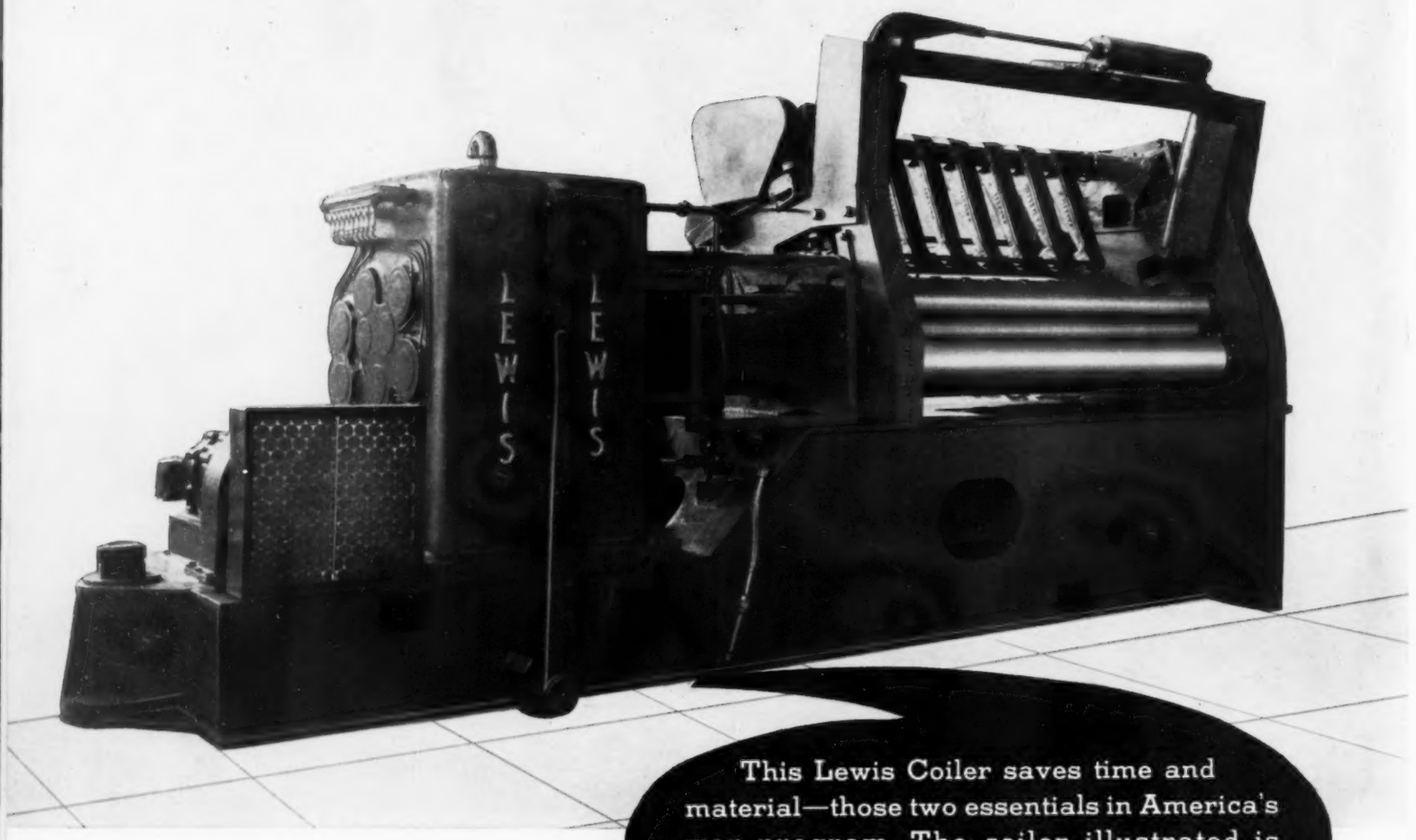


LEE WILSON ENGINEERING CO.
20005 LAKE ROAD · CLEVELAND, O.

• The Wilson Annealing Unit is covered by Patents Numbers 1952402, 2068477, 2078356, 2081612, 2089843, and other patents pending

New LEWIS Strip Coiler

ELIMINATES DANGER OF SCRATCHING



This Lewis Coiler saves time and material—those two essentials in America's war program. The coiler illustrated is being used to coil aluminum strip, which if scratched, is useless for many important purposes.

Features of the Lewis Three Roll Coiler:

Designed for coiling steel or non-ferrous strip up to 72" wide.

Coiler is equipped with guides, strippers and fibre lined pneumatic roller kick-off arms all especially designed to prevent scratching or other defacement of the material.

Steel forming and pinch rollers are hardened and ground. Top forming roller is equipped for individual or simultaneous adjustment on both sides through hand wheel and worm and worm gear. The machine is also equipped with side aligning rollers to keep the rotating coil straight at all times and has pneumatic simultaneous side adjustment through racks and pinions for widths from 24" to 72".

The machine is designed to swing in a semi-circle away from the mill or out of the strip line as may be required and is arranged with locking features to hold the unit in position. It can also be converted into a portable unit if desired.

LEWIS ROLLS step up tonnage

LEWIS FOUNDRY & MACHINE

DIVISION OF BLAW-KNOX CO.

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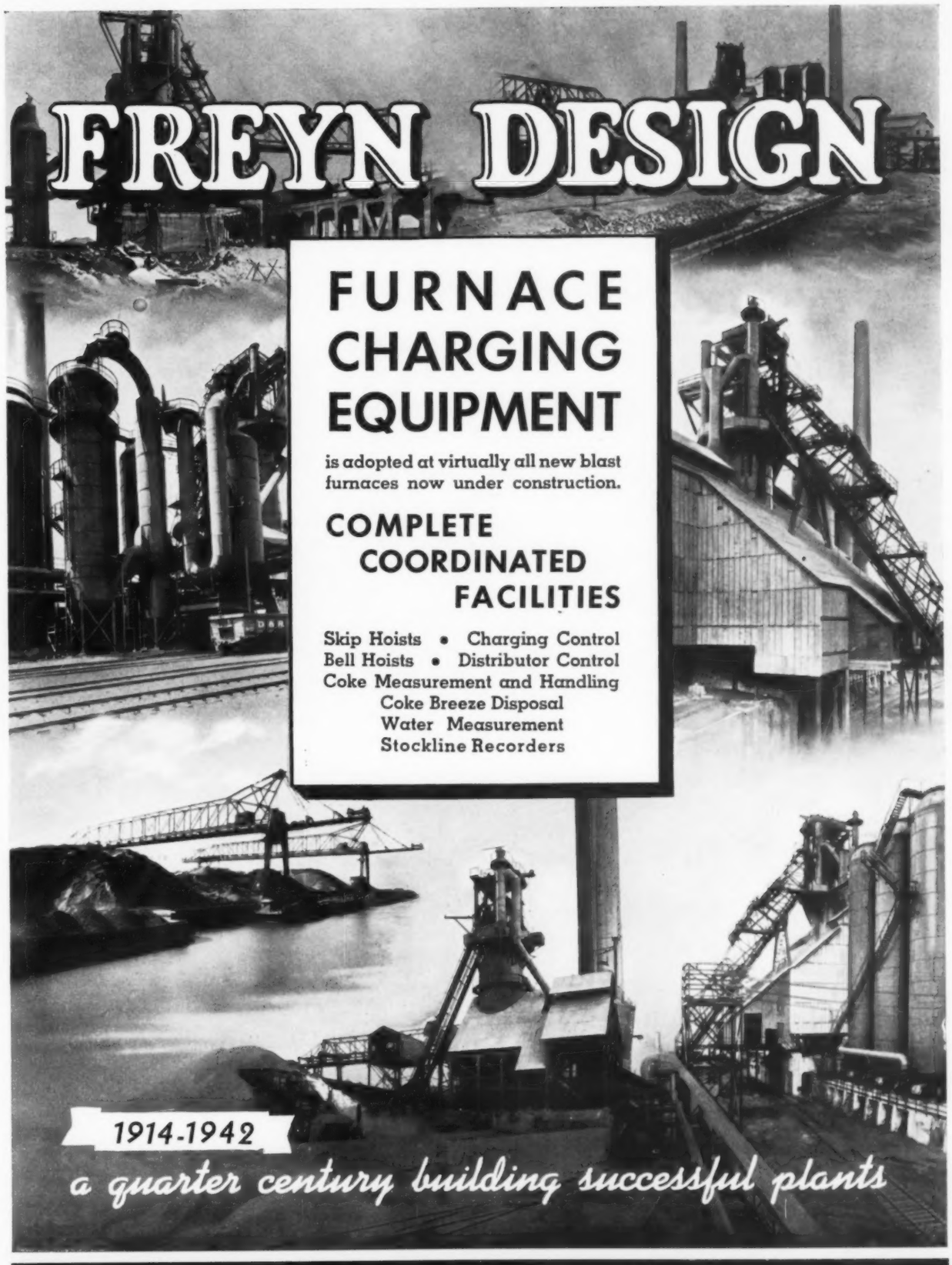

Freyn Engineering Company

CONSTRUCTORS — ENGINEERS — SPECIALTIES

310 SOUTH MICHIGAN AVENUE · CHICAGO U.S.A.

ASSOCIATED WITH:
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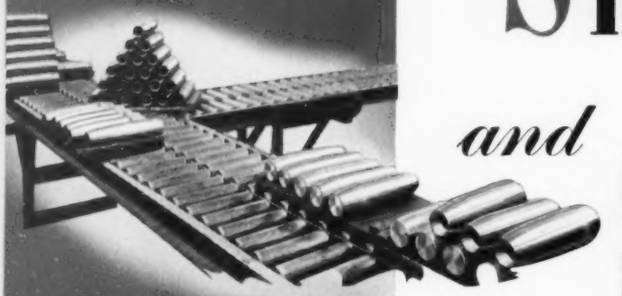
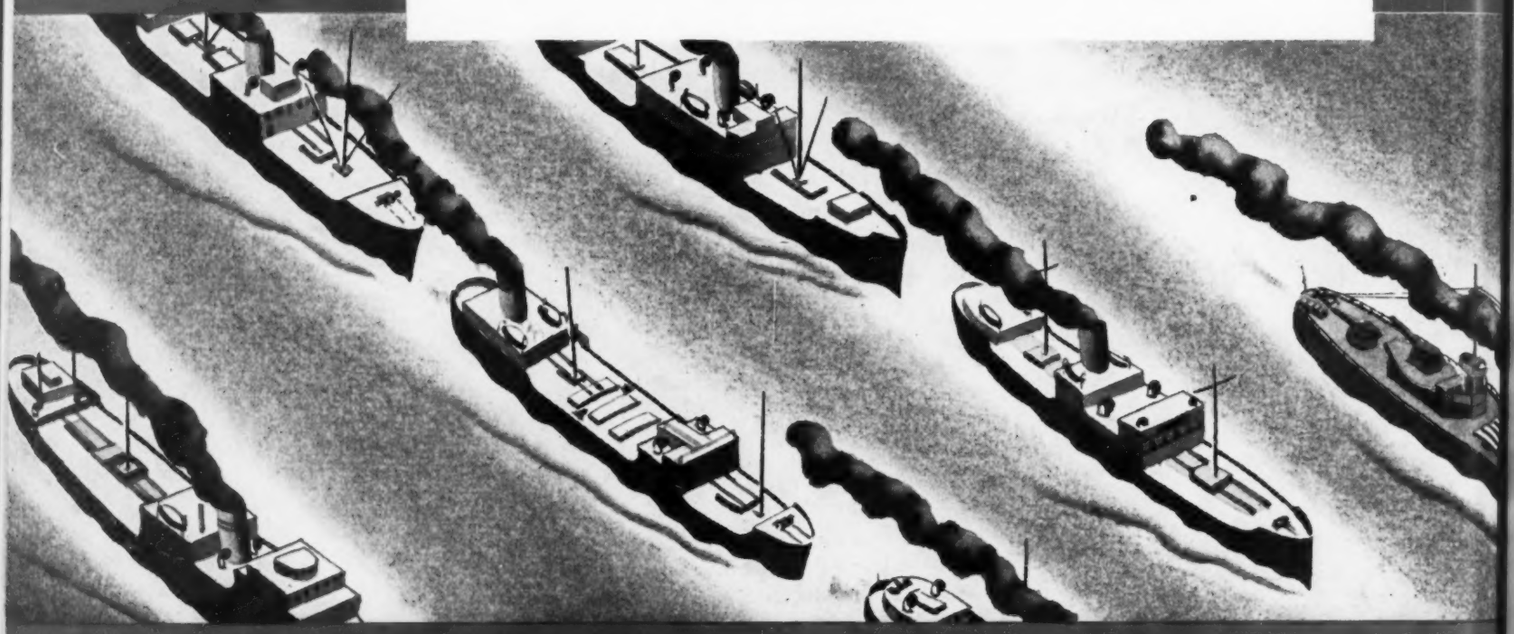


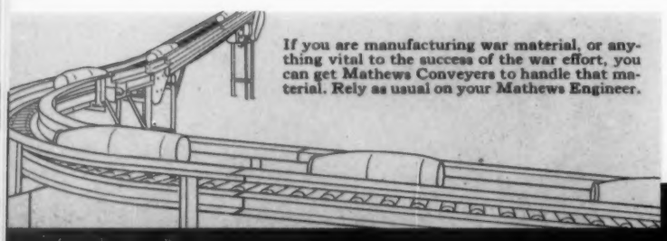
SHIP LANES *and* SHOP LINES



. . . Both Must Be Kept Open!

MATHEWS CONVEYER CO.

Ellwood City, Penna.



If you are manufacturing war material, or anything vital to the success of the war effort, you can get Mathews Conveyers to handle that material. Rely as usual on your Mathews Engineer.

● MECHANIZED SUPPLY LINES WITHIN THE SHOP have solved many war production problems. Where Mathews Conveyer Systems have been installed, not only have shop and assembly lines been kept open . . . they have been greatly accelerated . . . machine-and-man-hour production has been improved . . . worker fatigue has been reduced! Mathews Engineers are working every available hour toward the improvement of American war production.

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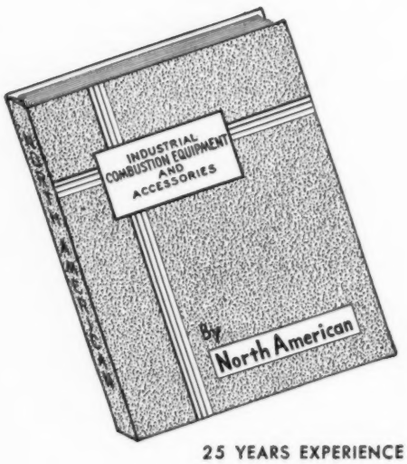

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MANUFACTURERS OF INDUSTRIAL FUEL BURNING EQUIPMENT FOR GAS OR OIL

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OHIO

New Developments in BLAST FURNACE CHARGING

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▲ Until the closing years of the 19th century, all blast furnaces were filled entirely by hand, except that a steam engine was employed to hoist the material from ground level to the furnace top.

The procedure for hand-filling a blast furnace was approximately as follows: Two-wheeled, iron hand-barrows were filled with ore, stone or coke, usually from overhead bunkers (though often by hand-shoveling from a stock pile), and wheeled onto a platform scale where the weight was adjusted to requirements. The weight of an empty barrow was about 800 lb. The ore barrow was loaded with about 1200 lb net; the coke barrow with about 600 lb net. The barrow was about 5 ft in height. Usually two men manipulated a 2000 lb barrow, although it was not uncommon for one man of adequate physique to do so.

From the scale the barrows were wheeled to the cage of a steam-driven hoist, and then were raised to the furnace top level. On the furnace charging platform were usually two, rarely one and often three or more top-fillers — men whose duty it was to wheel the loaded barrows from the hoist, dump them into the furnace hopper on top of the bell, with rigid adherence to prescribed sequence and peripheral position, and return them empty to the hoist.

The top-fillers constituted a considerably more skilled and highly paid class of labor than did the barrow men at the bottom of the furnace, because the operation of dumping, with which the top-fillers were entrusted, was of vital importance to the working and economy of the furnace.

It was primarily the inability of the top-fillers to keep pace with the ever-increasing tonnage demanded of blast furnace units and still observe the inescapable laws for stock distribution, that brought about the termination of hand-filling. The saving in labor cost was only an accessory cause, and a rather subordinate one at that. The change started in 1896. Labor was still plentiful and cheap.

Let us visualize the tempo of things on the charging platform of a blast furnace with the swelling of tonnage output. In the last decade of the 19th century, the average daily pig iron output of 153 Pennsylvania blast furnaces was 140 gross tons. In 1904, the 75 furnaces of the United States Steel Corporation averaged 370 tons per operating day. In 1910, 98 Corporation furnaces averaged 405 tons daily. In 1919, 109 Corporation furnaces averaged 450 tons per day, South Works making 535 and Duquesne 490 tons per operating furnace day. Contrast this with today's production of 1000 tons on many furnaces, and 1200 tons and more on others.

A furnace production of 150 tons per day requires 1230 barrow loads, while a production of 350 tons required 2880 barrows, and 450 tons needs 3700 barrow loads.

Visualize the hand manipulation of 2000 lb barrows shuttling about the comparatively narrow confines of the top platform of a blast furnace, in the more or less inevitable presence of asphyxiating furnace gas and under all conditions of weather.

When it became necessary to execute at breakneck pace the most important item in blast furnace operation, the one requiring the utmost in precision, hand-filling terminated and mechanical filling began. No one can name the exact tonnage point at which hand-filling becomes impossible. There are many 300-ton furnaces that are mechanically filled. There is one surviving hand-filled furnace in the Mahoning valley that averaged 438 gross tons of pig iron per day in November and December, 1940. There are 11 men per turn —top and bottom-fillers. The barrows are moved about with electric storage battery tractors. It might be called mechanized hand-filling. In more senses than one, it is the "last" word in hand-filling.

The changes from this design of blast furnace to the types we have today were gradual. About 1896, the first attempt to get away from pile distribution, as contrasted with annular distribution was made. With pile distribution, separate piles of different materials are deposited around the large bell. In 1896, at

Duquesne Works, the Neeland top was introduced, in which successive annular rings of material were deposited on the large bell by opening a small bell in the bottom of a skip bucket which traveled up an incline from the loading pit to the top of the furnace. The buggies were replaced by a power-driven scale car. The elevator became a skip hoist. At first, it was steam-driven, and later, motor-driven. The single bell was replaced by two bells and after various types of distributors were used, the McKee top became standard equipment for most furnaces. At first coke was handled through the scale car, the same as ore, but to save time it was later charged direct into the skip car from central bins. Still later came weigh-hoppers for measuring the coke.

During the last ten years many installations have been made wherein all these operations are coordinated and sequenced so that they are automatically controlled, with the result that only one man, or at most two, are required for filling the furnace.

Most of you are familiar with blast furnaces; however, let us briefly review the elements that make up the filling equipment for a modern 1200-ton blast furnace.

Ore and stone are charged into the scale car from pockets or bins having either hand-operated or power-operated gates. The scale car has two compartments, each having a separate hopper bottom. After the compartments are filled, the scale car is brought to the loading point at the skip pit and discharged into consecutive skips.

Coke is almost universally handled from central coke bins and is either charged direct into the skip car or is screened and measured in a measuring hopper from which it is charged into the skip car.

Stone is generally handled through the scale car, the same as ore, although in some instances it is charged direct from a central bin into weigh hoppers and then to the skip car.

After the skip car is loaded, the skip hoist pulls it to the top of the furnace where it is dumped onto the small bell. In most plants the preceding skip-load is held on the small bell until the ascent of the succeeding skip. The small bell is required to open and close during the ascent of the skip car.

Immediately after the skip car at the top of the furnace has unloaded its charge into the small bell receiving hopper, the distributor rotates. While it is revolving, the small bell must be held closed.

If the stock house and scale car operations are not the bottleneck, some time may be saved by letting the skip start while the distributor is operating. With a reversing distributor, there is sufficient time to accomplish all rotation angles except the 180 deg. angle, as well as the operation of the small bell during the ascent of the skip. For the 180 degree angle, the skip is held in the pit for the first 60 degrees of distributor movement. This method of interlocking is new and will go into service on two furnaces in the near future.

After a predetermined number of small bell loads have been placed on the large bell, the latter is dumped, placing the charge on the stock in the furnace.

The blast furnaces of today are being equipped with larger skips. In some cases higher skip speeds, up to 600 fpm, are provided for. Bells are made larger, but their speed of operation is not being increased on account of the effect of bell speed on distribution, and also because there is a definite practical limit to safe operating speeds for this ponderous kind of equipment. Too often the distributors are operated in one direction only, instead of using a reversing type with its resultant time saving.

In too many instances full consideration is not given to what is the actual bottle-neck in the filling operation. In the majority of cases this bottle-neck is in the stock house. The limiting factor is the time taken to get the proper amount of ore out of the ore pockets and transport it to the skip car at the loading pit. A high speed skip hoist does little good if it waits for the furnace top mechanism, or it it waits for the scale car to bring up the ore load. Likewise, it is not rational to compensate for deficiencies in the distributor or in the stock house by speeding up the skip hoist. The bottle-neck itself should be removed.

After determining the rate at which the filling of the furnace must be accomplished, each element of the filling equipment should be designed with the idea of operating it at as moderate a speed as is consistent with conservative practice and with a reasonable margin of adequacy, and yet keep in step with the remainder of the furnace filling equipment. To put it bluntly, the design of the furnace filling equipment all too often requires a little more rationalization.

One of the ways to secure rationalization is to make more of the operations automatic, not alone due to the saving in man-power but because of the saving in time. An operation done automatically is always done on time, while a manual operation is sometimes on time, but not always, particularly on the night shift. Automatic operation is now being applied to the skip, the bells, the charging and measuring of coke, the measurement of stock water, the measurement of the burden level, the functioning of the breeze hoist and related equipments. In filling the modern furnace, the only manual operations are loading and unloading the scale car, and these operations are under the control of the scale car operator.

Let us now take up the various items of furnace filling equipment and discuss them with special attention to the modern method of control for each item. The scope of this discussion will not include the ore and stone bins, nor the scale car. Neither will the skip hoist be included. The latter is a subject about which a great deal may be said.

Bell Hoist

Of the many blast furnaces that have been rebuilt during the last two years, more than 80 per cent have used the pneumatic bell hoist powered by cold blast air. This preference is a gradual growth. The pneumatic bell hoist has been available for some time, but it did not reach its present improved form until about four years ago.

The reasons for the preference of the pneumatic bell hoist are interesting. Operation of the bell requires a slow reciprocating motion. A cylinder of some description operated by steam, oil, water or air is therefore a natural form of operating mechanism. On the older types of furnaces the large bell is held closed by a

weight. A steam cylinder is used to lift the counterweight, thereby opening the bell. The small bell is generally operated by a double-acting steam cylinder. Many furnaces still use this construction, although it is rapidly being abandoned on account of the sluggish bell operation obtained due to condensation of steam in the bell operating cylinders.

A later development was the use of high-pressure oil cylinders. This gave smoother operation with accurate speed control, but many plants objected to the maintenance of oil lines, the accumulator, and oil pumping machinery, to say nothing of the fire hazard on top of the furnace in the event of an oil leak. Nevertheless, there are still a few oil bell hoists in use.

There is objection to having the bell operating mechanism on top of the furnace. Consequently, the next step was to put the steam cylinders at ground level and place them in a house, thereby partially alleviating the condensation trouble. Meanwhile, the motor-driven bell hoist came into the picture. To obtain slow reciprocating movement, an early design of the electric bell hoist used a long screw with a traveling nut. Later designs used variations of cranks, as well as an arrangement involving a combination of two drums and two cranks driven by a single motor for operating both bells. The motor-driven bell hoist faces the problem of converting relatively high speed rotary motion to slow reciprocating motion. Consequently, it cannot ever attain the simplicity of the direct-acting cylinder.

About the time that the steam cylinders were being moved from the top of the furnace to ground level, the low-pressure pneumatic bell hoist operated from cold blast air came into existence. The advantages that accelerated the development of the pneumatic bellhoist are the following:

With the exception of the steam or air cylinder located at hoist house or ground level, all bell operating mechanisms depend upon a heavy counterweight placed on the large bell lever or connected to the large bell by means of a cable for holding the large bell closed not

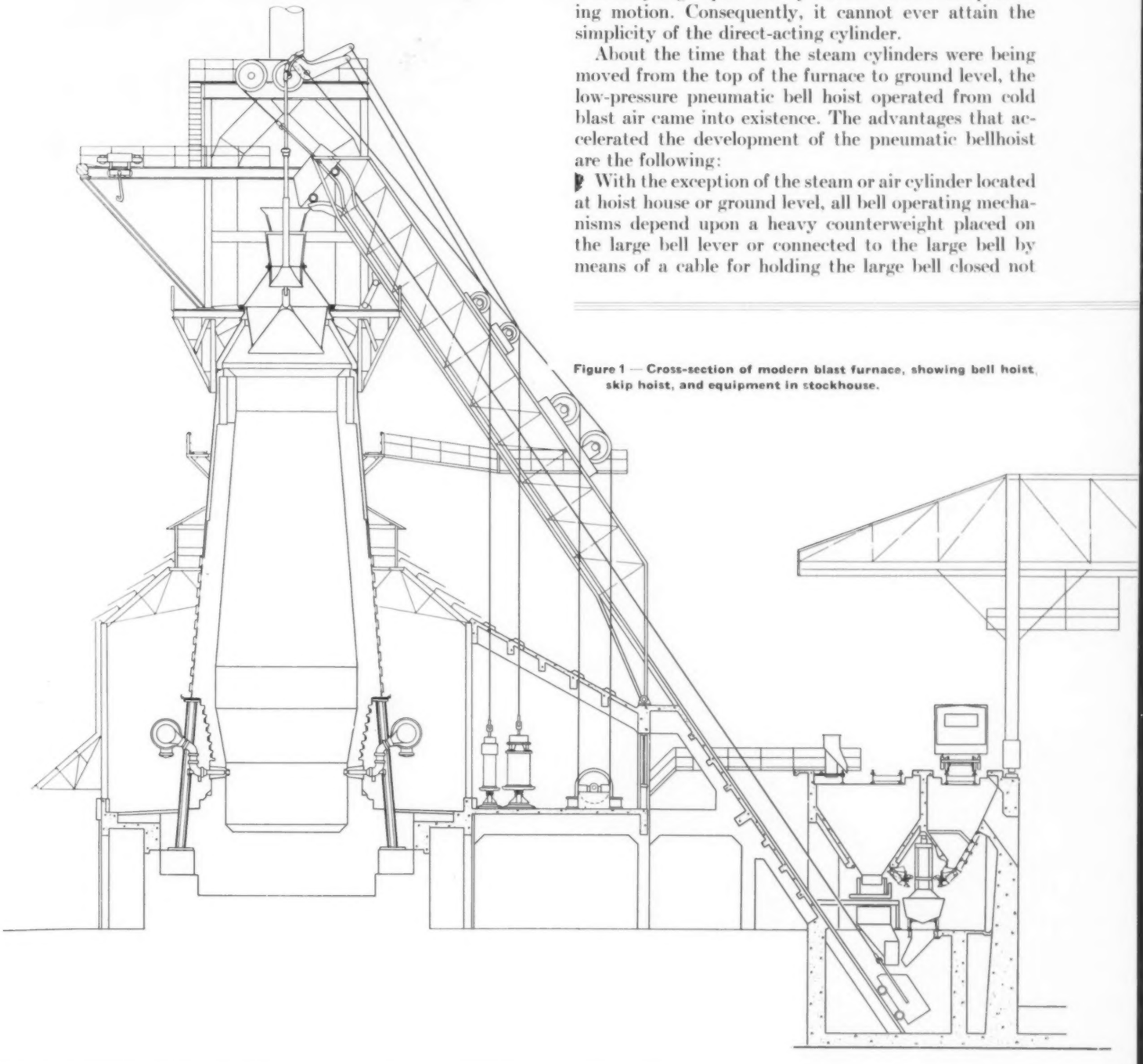


Figure 1 — Cross-section of modern blast furnace, showing bell hoist, skip hoist, and equipment in stockhouse.

only when it is empty, but also when it is loaded. As a result, a very heavy counterweight is required, running on a modern 1200-ton furnace to approximately 25 tons.

In the event of the ignition of an explosive mixture of gas and air forming in the hopper above the large bell and below the small bell, the usual way for the explosion to relieve itself is to open the large bell, whereupon the pressure passes into the top of the furnace and out through the gas uptakes. This subjects the bell rods and levers to excessive stress, especially since the heavy counterweight resting on the large bell lever must not only be lifted, but, in addition, accelerated. After the explosive pressure is relieved, the bell slams closed under the influence of the counterweight. If the bell has been opened very wide by the explosion, the stress on the bell mechanism in closing is often sufficient to break the bell rods, the bell levers, or knock the counterweight loose, with resulting severe damage.

With the pneumatic bell hoist, the empty bell is counterweighted only by the weight of the bell cylinder and a small amount of additional counterweight. The weight of the load resting on the large bell is largely held by the air pressure within the bell cylinder. In the event of an explosion on a pneumatic bell hoist, there is not nearly so much mass to be lifted and accelerated, thereby greatly relieving the stress on the bell mechanism during the opening movement. In addition, the air in the cylinder is a compressible medium, permitting the bell cylinder to move and open the bell while compressing the air in the cylinder to a higher pressure. Mounted on the bell cylinder is a relief valve, which relieves the air pressure in the cylinder rapidly in the event that the air in the cylinder is compressed much over normal pressure.

When an explosion occurs on a large bell driven by a pneumatic bell hoist, the air cylinder is quickly raised and the excess pressure in the cylinder is relieved. When the explosive pressure in the bell hopper has been relieved by the opening of the bell, the pneumatic bell hoist closes the bell at normal speed under the influence of the cold blast air pressure, just as though a normal closure were taking place. There is no excessive strain on the equipment. We are not talking about theory when we make this statement. These facts have been definitely proved in practice. The large bell cylinder has been raised rapidly due to the force of the explosion and the air pressure in the cylinder has blown out through the relief valve. The cylinder has then closed slowly, as in the case of normal operation.

From a safety standpoint, it is in general undesirable to have bell lever counterweights on top of the furnace. If the bell operating mechanism of one type or another is placed in the hoist house or at ground level, it is possible to locate the counterweight at this level, thereby eliminating the hazard of a heavy counterweight located on top of the furnace. With the pneumatic bell hoist, a comparatively small amount of counterweight is required, inasmuch as the air cylinders are double-acting and the air pressure supports most of the load which is placed on the bells.

As previously explained, the movement in opening or closing the bells is a slow reciprocating motion. An air cylinder is the simplest means of getting this action. A pneumatic bell hoist cushions the bells during operation. The flow of air is controlled on both sides of the piston in the double-acting cylinders, thereby preventing the bells from being violently opened or slammed closed. The bell seats itself gently on the seat. No limit switches are required to stop the bell movement inasmuch as the cylinder itself limits the travel of the bell.

Figure 2 — Pneumatic hoist and motor operated valves for controlling bell hoist.

The pneumatic bell hoist requires a comparatively small floor space, inasmuch as the air cylinders are vertical and are relatively small in diameter. In the pneumatic bell hoist, the piston and piston rod are stationary when the cylinder moves. This design utilizes the weight of the heaviest part of the bell hoist as part of the counterweight for counterbalancing the empty bell. Also, this design permits the use of the top of the bell cylinder as a convenient place for locating the additional counterweight that may be required. It will be noted that this design of bell hoist requires no pit or guide for the counterweights.

The speed of a pneumatic bell hoist is under definite control during both the opening and closing movement. This is accomplished through the use of separate discharge lines for each direction of travel of the bell cylinder. By throttling the discharge air, it is possible to adjust the speed to any desired value for the opening stroke of the bell and then, by the use of another discharge valve which controls the discharge for the closing stroke of the bell, the closing speed of the bell can be adjusted without affecting the opening speed. The ability to adjust the bell hoist speed very quickly has proved to be highly desirable.

The bells are operated normally on cold blast air which is controlled through a reducing valve to give 15 psi pressure. As a reserve, the plant compressed air is brought in and reduced by a separate reducing valve to 14½ psi pressure. With this arrangement, the cold blast supply operates the bells until its pressure drops below 14½ psi, whereupon the compressed air supply automatically takes up the load without attention. This

enables the operation of the bells when the furnace is checked, should such be required.

The pneumatic bell hoist has low maintenance, inasmuch as the only points of wear are the stuffing box around the piston rod and the cylinder rings on the cylinder walls. Since the air pressure is low, the maintenance of these items is almost negligible.

Cold blast air is undoubtedly the cheapest form of power available at the blast furnace plant. Only a few cubic feet of air are required for a complete movement of the bell cylinder. Cold blast air is furnished to the furnace at the rate of 60,000 to 90,000 cfm, and 30 or 35 additional cfm at intervals of one or two minutes apart are insignificant. Cold blast air is the most reliable form of power around the blast furnace, for the furnace cannot operate in the event that there is no cold blast.

It is of course possible to control the bell hoist operation by actually having a man work the bell valves directly. It is far more convenient, however, to use a motor-driven operator for controlling the valves. Ordinarily, two three-way valves are controlled by a ½ hp motor which drives a crank. The motor-driven operator may be run in the same direction for opening and for closing the valves. This valve operator may be controlled through the medium of a push-button, or should we desire to have the bells operate automatically in conjunction with the skip hoist, we may use the blast furnace charging control.

Blast Furnace Charging Control

The blast furnace charging control coordinates, sequences and interlocks the operations of the skip hoist, distributor, small bell hoist, large bell hoist and stockline recorder, so that all of these pieces of equipment will operate without any assistance on the part of an operator other than the pushing of a button after the skip car has been loaded. Specifically, the blast furnace charging control performs the following functions:

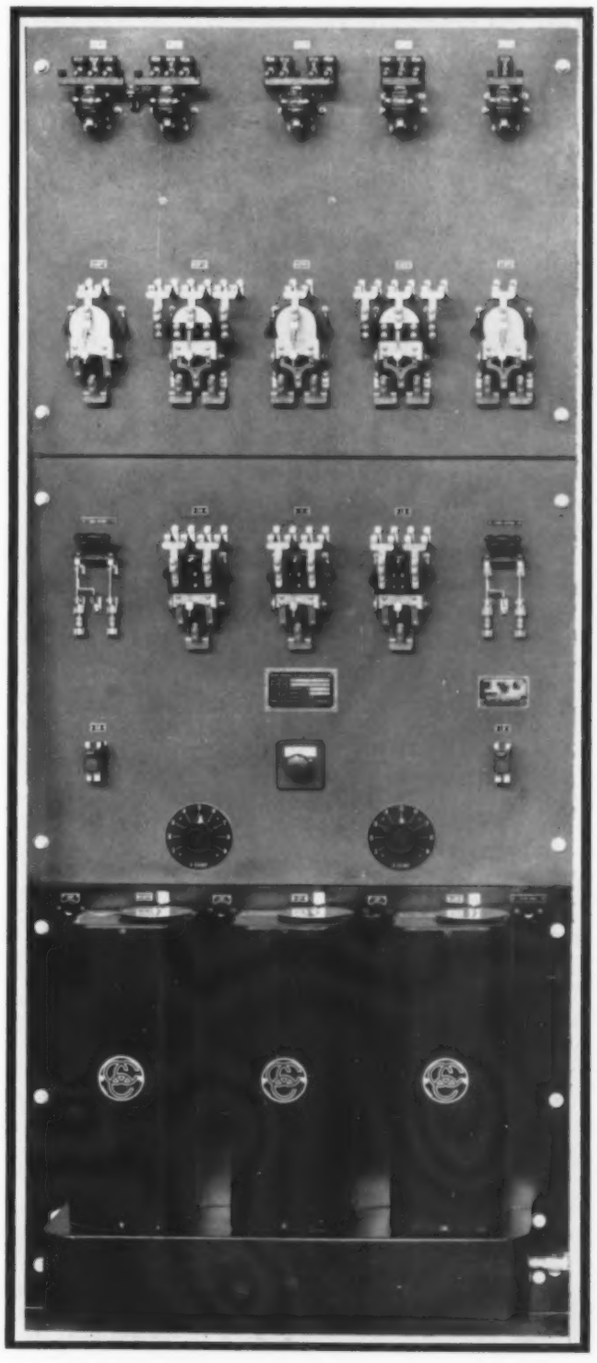
A. It acts as an automatic car switch and selects the proper direction of rotation for the skip hoist. It also interlocks its operation with other events in the sequence of operations
B. It initiates the distributor operation through the medium of the distributor control and interlocks the distributor operation with both the skip hoist and the small bell operation.
C. It controls the small bell hoist operation and sequences its operation with the skip hoist and interlocks it with the operation of the large bell.
D. It initiates the hoisting of the stockline recorder test rod before the opening of the large bell.
E. It controls the large bell hoist operation after the small bell has made a pre-set number of dumps.

The sequence and interlocking between these various equipments is obtained by using:

A. Contacts in the skip hoist limit switch to show when the skip is at slow-down and when at final stop.
B. Interlocking switches placed on the bell hoist to show when the bells are in the open and in the closed positions.
C. An interlocking switch on the distributor control to show when the distributor operation is completed.
D. An interlocking switch on the stockline recorder limit switch to show when the test rod is in the raised position at the top of the furnace.
E. Program switches which set up the required sequence of operation.

The heart of the blast furnace charging control is the motor-driven program switches or cam switches, one for controlling the small bell and skip, another for

Figure 3 — Blast furnace charging control panel.



counting the operations of the small bell, and the third for controlling the large bell and stockline recorder. These program switches are in reality rotating cam switches, as shown in Figure 4.

Mounted in the cam switch housing is a square shaft with the ends turned down for support by needle roller bearings held in the housing. On this shaft are mounted bakelite cam supports which carry hardened steel butterfly cams. These cams are made in six different lengths, which are adjustable to give any degree of contact closure that is desired. These cams run against drill rod rollers which in turn operate the contact fingers. Silver-to-silver double-break contacts are used, thereby eliminating the need of pigtail connectors. The assembly is so arranged that the contact is held closed by a strong spring and is opened by the raised portion of the cam coming against the roller on the finger.

The butterfly cams are set at the factory to insure the correct sequence or order in which the contacts are to be made and broken in the cam switch. Each cam switch is driven by a motor-driven operator mounted on the back of the control panel.

In Figure 3, the program switch or cam switch at the extreme left is known as the small bell program. There are eight positions on this program, the first four of which control the hoisting of the left skip car and related operations of the distributor and small bell, while the remaining four positions control these operations for the right skip car. The function of each position is given below:

Position I — With the left skip in the pit, pushing the skip-start push-button causes the small bell program to move to Position II.

Position II — If the distributor has completed its operation, an interlocking relay on the distributor control will complete a circuit permitting the small bell program to turn through Position II to Position III.

Position III — Contacts are actuated in this position to cause four operations:

1. One cam in the program switch completes a circuit causing the skip hoist to send up the left skip car.
2. Another cam closes a circuit causing the small bell to open, provided the large bell program is in a position showing the large bell to be closed.
3. The counting of the dump of the small bell is initiated.
4. Provided the counting relays have been set to initiate the count, and after the small bell is completely opened, as shown by a closure of an interlocking switch placed at the top of the small bell cylinder travel, the program switch moves to Position IV.

Position IV — Three actions take place:

1. The counting of the dump of the small bell is completed by actually operating the counting program.
2. If the skip has left the pit, and when the small bell is closed, as shown by closure of an interlocking switch placed at the bottom of the small bell cylinder travel, the program moves to Position V.
3. However, if the skip should reach slow-down before the small bell is closed, it will be stopped and held at slow-down until the small bell is closed, after which the small bell program moves to Position V and the skip is permitted to resume its travel to final stop.

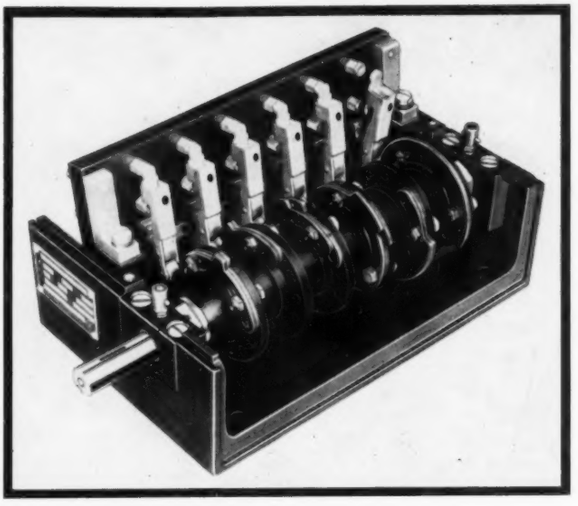


Figure 4 — Rotating cam switch used on blast furnace charging control.

Position V — Positions V, VI, VII and VIII duplicate the operations of Positions I to IV inclusive, except that the right skip is sent up instead of the left skip.

The counting program, or the center cam switch in Figure 3, is forced to rotate one point for each half-revolution of the small bell program, i.e., for each dump of the small bell, thereby counting the loads that are deposited on the large bell.

There are two dump selector switches provided, by means of which it is possible to pre-select the number of loads that are dumped by the small bell prior to a dump of the large bell. Use of two selector switches permits the use of a split round in which the number of loads dumped in the first half of the round may be different from that dumped in the second half of the round. For example, a split round might have four dumps of the small bell which, after a dump of the large bell, is followed by six dumps of the small bell, with a dump of the large bell immediately thereafter.

When the counting program has counted a number of loads equal to that set on the dump selector switch, a circuit is completed which causes the large bell program to move one point, thereby initiating a large bell operation.

The large bell program turns a half-revolution to control all of the operations required to secure one dump of the large bell. The "A" dump selector, or the one at the left in Figure 3, controls the first half-rotation of the large bell program, while the "B" dump selector, or the one at the right in Figure 3, controls the second half-revolution of the large bell program. The following are the events that take place on the large bell program:

Position I — In turning from Position I to Position II, the large bell program breaks a circuit which prevents the small bell from operating again until the large bell operation is completed.

Position II — In this position, three events take place:

1. The counting program is re-set to zero by running the counting program motor until the zero position is reached.
2. Causes the withdrawal of the test rod.
3. After the test rod has been completely withdrawn, as indicated by the test rod limit switch, the large bell valve operator is manipulated by its motor so as to cause the large bell to open, provided the small bell is closed. When the large bell is open, as indicated by the interlocking switch at the top of the bell cylinder travel, and provided the counting program has been re-set to zero, the large bell program moves to Position III.

Position III — In this position, the large bell valves are again manipulated so as to reverse the air supply and to cause the large bell to close. When the large bell is closed, as indicated by the interlocking switch at the bottom of travel of the large bell cylinder, the program moves to Position IV.

Position IV — In Position IV, as in Position I, the small bell is again permitted to resume its normal operation. When sufficient dumps of the small bell have been made to cause the counting program to complete a circuit through the "B" dump selector, the large bell program moves from Position IV to Position V.

Position V — The actions taking place in Positions V and VI duplicate those taking place in Positions II and III. In other words, a second dump of the large bell is obtained. When the large bell has completed its operation, the large bell program moves to Position I.

It will be noted from the foregoing that a definite sequence is set up by the program switches and that this sequence is forced, i.e., not only is a definite sequence of events commanded, but a check is made at each step to insure that this command or step is completed before the next is started. For example:

1. The small bell is ordered to dump during each ascent of the skip, and if the small bell dump is not completed, the skip is held at slow-down until the small bell dump is completed.
2. The counting program is forced to count each small bell dump before the small bell is permitted to close.
3. The skip must complete its ascent and must dump before the other skip can be sent up, thereby preventing the lowering of a loaded skip.
4. The distributor must actually start and must complete its operation before the small bell can dump.
5. The large bell must dump after the required number of dumps of the small bell, otherwise the small bell is prevented from dumping. This in turn stops the skip at slow-down.
6. The test rod must be hoisted to its uppermost position before the large bell can dump.

There are times when it is desired to cut out the automatic control of the charging equipment, as for instance, when checking the operation of the skip hoist, or for inspection of the bells, or for the purpose of clearing material that may adhere to the bell seat. For this reason a transfer switch is provided which cuts out the automatic control and enables each piece of the filling equipment to be operated independently of the other and under manual control. The skip hoist can than be operated from its own car switch. The small bell hoist is operated by means of push-buttons working the bell valve operator, and the large bell is similarly controlled. When the filling equipment is operated a manual control, the program switches do not operate.

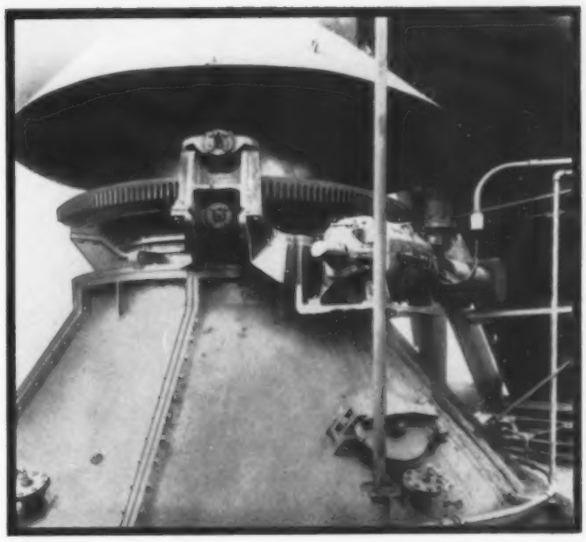


Figure 5 — View showing McKee revolving distributor.

There are times when the scale car operator desires to charge an extra load, i.e., one that will not be counted by the counting program, thereby enabling one or more loads to be added to the large bell prior to a dump of the large bell. When it is desired to charge extra loads, the extra-load push-button is pressed for each extra load that is charged. Each time this extra-load push-button is pressed, it is possible to charge one load without counting it.

There are times when the operator wishes to cut the round short of the normal number of the small bell dumps. By pushing the charging re-set push-button, the large bell program is caused to dump the large bell and re-set the counting program to zero, thereby enabling the starting of a new round.

There is the possibility that the top pressure on the furnace might be sufficiently high to support the large bell and its load when the large bell cylinder operates to open the bell. This would cause the large bell cylinder to rise, giving slack cable on the large bell. Should the top pressure then fall sufficiently to permit the bell to open, it would drop and probably cause damage to the bell levers and operating rig. To prevent this possibility, a slack-cable device is incorporated in the bell control so that in the event of slack cable, the slack-cable switch is tripped, resulting in reversing the air supply on the large bell cylinder and holding it closed until the slack-cable switch is re-set and the trouble eliminated.

Distributor Control

The function of a distributor on a blast furnace is to disperse and thereby equalize any inequalities that may exist in the size, quantity, or relative placement of materials that are charged onto the small bell. Experi-

ence gained with the hand-filled furnace has set down certain empirical laws covering the manner in which stock should be distributed in the blast furnace:

Law No. 1. The distribution of each kind of stock must be symmetrical about not less than two axes making equal angles with each other.

Law No. 2. The same proportion of lump and fine must obtain in each of the segments into which the circle of the top is cut by these equal-spaced axes.

Law No. 3. The distribution of fine and coarse material radially must be such as to produce as nearly as possible an equal ascent of gas through each portion of the furnace stack.

In all types of mechanically-filled blast furnaces there is something that rotates, so as to give distribution of the material to conform to the above laws. With the Neeland design, a bucket is carried up the skip incline and unloaded by opening a bell in the bottom of the bucket. This bucket is rotated in the stock house either while being loaded or, after being loaded, it is rotated to different positions on successive loads. The Brown top was made to accommodate the skip car as we know it today, in which the car is inverted so as to dump its contents. In this top there is a movable chute which moves to a new position for each skip-load. This top discharges the material in an outward radial direction so that the material is deposited in successive piles around the large bell.

During the first decade of this century came the McKee top. It is a fixed, rotating, skip-filled top like Brown, but it discharges over a bell in all directions like Neeland. The rotating features of the McKee top is for the purpose not of wiping out the inequalities in quantitative and size distribution that prevail when a skip tub is dumped over the side of the receiving hopper, but rather of making each and every sector of the furnace's horizontal cross-section receive these inequalities in succession, and so share them alike. In this respect the McKee top faithfully lives up to the spirit of the laws of distribution in blast furnace charging.

The use of the McKee top has grown steadily during the past thirty years, until today it is the predominating equipment, in its functional sphere, on American blast furnaces.

It is standard practice to have six positions to which the McKee top is rotated after the material has been charged into the small bell hopper. These six positions are equally spaced 60 degrees around the top. Let us take a round of five charges comprising ore, ore, stone, coke and coke, after which the large bell is dumped. The usual practice would then call for five loads to be charged at the zero position, followed by five loads at each of the other five positions consecutively. In other words, after five loads have been put in at the 0 degree position, each of the next five loads would be rotated 60 degrees after the load had been completely discharged into the small bell hopper. The next five loads would be rotated 120 degrees; the next five loads would be rotated 180 degrees; the next five loads would be rotated 240 degrees; and the last five loads would be rotated 300 degrees. This completes a complete cycle of the top rotation, after which the same cycle is repeated.

While six positions have been chosen, a lesser number could have been used, but the dispersion of any inequality would not be as good as can be obtained with six positions. A greater number than six positions could be used, but experience has shown that the larger number of positions does not result in bettering the performance sufficient to warrant the increased complication.

There are three functions of the distributor control. These are:

A. Selection of the angle through which the top is to be rotated.

B. Initiation of the distributor operation at the proper time in the cycle.

C. Measurement of the angle through which it is rotated.

Let us consider first the selection of the angle through which the top is to be rotated. The angle is selected by the angle selector program, which is a six-pole cam switch. The cams operating these poles are so arranged that cam No. 1 is closed for 0 degrees, cam No. 2 for 60 degrees, cam No. 3 for 120 degrees, etc. These cams are spaced one-sixth of a revolution, or 60 degrees, apart. Each of these cams when closed sets up a separate circuit through one of the counting relays (hereafter described) to the directional contactors.

Most furnace operators desire to have all of the loads that are charged on the large bell rotated through the same angle, i.e., they desire to change the angle after each dump of the large bell. In some instances, where split rounds are charged, in which the number of loads placed in the first half of the round is different from that in the second half of the round, they wish to change the angle only after every second dump of the large bell. For instance, if a round comprises five dumps of the small bell after which the large bell is dumped, and four dumps of the small bell followed by a dump of the large bell, they would desire the angle of rotation to be changed after nine loads had been completed, i.e., after the second dump of the large bell.

In our previous discussion of the blast furnace charging control we have shown how the large bell is controlled through the large bell program switch. This program rotates a half revolution for each dump of the large bell. It is relatively simple to gear the angle selector program of the distributor control to the large bell program so that at each dump of the large bell the angle selector program is turned to the next position, i.e., 60 degrees away from the position in which it was standing, thereby selecting the new angle of rotation. This is accomplished by means of 3:1 gear ratio between the two programs.

Should the operator, however, desire to have the angle changed after each second dump of the large bell, as might be the case with a split round, the gear ratio between the two programs is changed from 3:1to6:1 by means of a change gear, thereby making the angle change after each second dump of the large bell.

This manner of changing the angle forces absolute synchonization between the distributor operation and the large bell operation, insuring that all loads charged onto the large bell are rotated through the same angle without any attention on the part of the operator.

There are times when it is desired to operate the large bell without changing the angle of rotation, as for example when the large bell is opened for inspection purposes, or is opened for clearing any material that

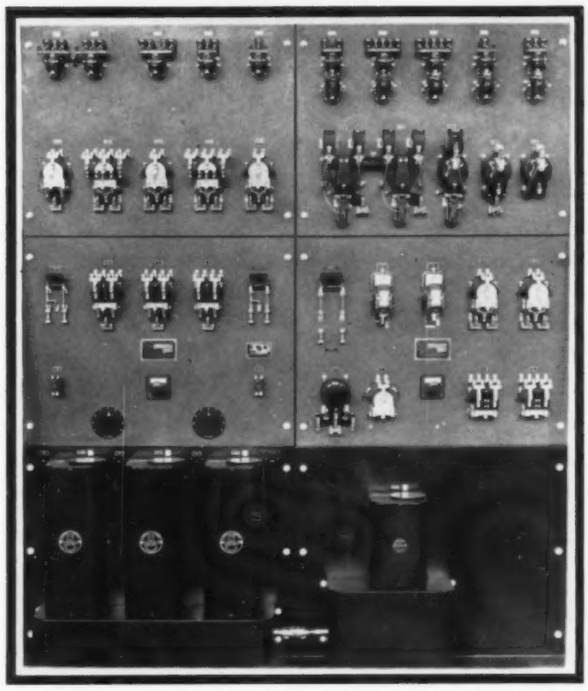


Figure 6 — Control panels, showing charging control at left and revolving distributor control at right.

might be caught on the seat of the bell. These extra operations of the large bell are obtained by manual control of the bell, rather than on automatic operation. On manual control, the large bell program is not rotated. Therefore the distributor angle of rotation will not be changed.

While practically all operators with whom we have been in contact desire to have all loads charged onto the large bell rotated through the same angle, we have found one company in which the operators wish to have part of the loads placed on the large bell rotated through one angle, while the remainder of the loads are rotated through the next angle in progression. In such event, it is necessary to provide a device for counting the number of skip-loads. The load-counting device is similar to that used for counting the dumps of the small bell on the charging control. We must use a separate load-counting device, however, for the operators desire to change the angle at a time different from that at which the large bell is dumped. It will be remembered that the large bell is dumped at the instigation of the counting program on the charging control.

The load-counting program is geared to the angle program with a 6:1 ratio, such that a complete revolution of the load-counting program rotates the angle selector program from one position to the next, i.e., 60 degrees. If the number of loads at which it is desired to change the angle of rotation is five, the load selector switches will be set at five. When five loads have been counted, the counting program will be rotated forward to 0 degrees, i.e., it will make a complete revolution, thereby changing the angle of rotation on the angle selector program.

With this type of control it is necessary to take care of extra loads by means of an extra-load push-button switch to prevent the extra loads from being counted by the load-counting program. The same extra load push-button switch used for the charging control accomplishes this result, so there is no difficulty on this score.

Initiation of the distributor operation is accomplished by a limit switch on the skip hoist, which closes a contact at final stop of the skip hoist. This closes a relay which is latched closed until the complete distributor operation has been performed. This relay in being latched closed, prevents the skip hoist and the small bell from operating until the distributor operation is completed.

It is imperative that all of the material from the skip tub be discharged into the small bell receiving hopper prior to the distributor rotation. Otherwise, for small loads we will obtain a peak on the pile as desired, but on large loads the material will still be discharging into the hopper while the distributor is still turning, thereby affecting the uniformity of distribution. Standard practice provides for a dumping time of approximately 10 sec to insure that all material has dropped free from the skip tub prior to the initiation of the top rotation. There are several types of timing relays, the most successful of which are the vari-time, hermetically-sealed, oil dash-pot relay, or the mercury dash-pot relay, both of which are commonly used for this purpose.

We have now initiated an operation of the distributor after having previously selected the angle through which it is to be turned, and after locking out the operation of the hoist and small bell, as well as having insured that the skip-load has completely dumped into the small bell hopper. The distributor motor has been started, accelerated and brought up to speed. It is now necessary to determine when it should be stopped, i.e., the angle of rotation should be measured. One method for accomplishing this is by timing the rotation of the top, i.e., to allow it to rotate for a definite time. A timing relay can be set to stop the motor after a time interval which has been found to give a 60 degree rotation. The disadvantage in this method lies in the variation in the angle turned, caused by variations in load, in frictional resistance, and in voltage variations which affect the motor speed. Frictional resistance is affected not only by the packing gland on the rotating top, but also by the frictional resistance in the top mechanism itself in cold weather as compared to warm weather. In a timer installation which we have built, we found it necessary to check the distributor rotation daily in order to insure that the required angle was consistently turned. This variation was in no way occasioned by the inaccuracy of the timer, but rather by variations in the number of degrees through which the distributor could be rotated in a given time.

The accurate method of determining the distributor rotation is by actual measurement of the degrees of rotation, using a hopper switch. The hopper switch is geared so that is makes one rotation for each 60 degree movement of the revolving top. With such an arrangement, it is only necessary to provide a method of counting the number of hopper switch revolutions, i.e., the number of 60 degree increments of top rotation. For instance, if the angle selector program calls for 180 degree movement of the top, three 60 degree increments

of movement must be counted. This is accomplished by the use of counting relays. Three of these are provided. The first relay closes only on the first revolution of the hopper limit switch. The second relay will close on the second revolution, and the third closes on the third revolution of the hopper limit switch. These are latched relays and remain closed until re-set by the operation of the small bell, thereby preventing repeat operation of the distributor on the same load for any reason whatsoever. When the number of 60 degree increments called for by the angle selector program has been completed, the last latch relay to close will interrupt the circuit set up by the angle selector program to the directional contactors, thereby shutting down the distributor motor and tripping out the small bell relay which initiated the distributor operation and which locked out the skip and small bell from operating. This permits the skip and small bell to be operated when called upon for their normal operation.

Some distributors operate in only one direction. It has been found, however, that a time saving can be accomplished by reversing the distributor for the 240 and 300 degree angles of rotation. To make a 300 degree rotation normally requires five increments of 60 degrees, or about 25 sec. Insofar as the distributor is concerned and the effect on the distribution obtained, it does not matter whether the top is rotated backwards 60 degrees to arrive at the 300 degree position, or forward 300 degrees, but the time in one case is only 5 sec while in the other case it is 25 sec. Inasmuch as the small bell must be prevented from operating while the top is rotated, and likewise the skip is also prevented from operating, it is desirable to cut the distributor operating time to as small a value as possible in order to speed up the furnace charging.

Dynamic braking is now almost standard on distributor controls inasmuch as the braking effect is then independent of operating conditions. Shoe brakes have been used, but the braking power depends entirely upon the condition of the brake lining and weather conditions. It is important that the braking effect be constant in order to provide accurate stopping of the top.

Most revolving distributors are driven by series motors inasmuch as this is the simplest type of mill motor and requires the fewest leads. However, there are some compound motor installations and their number is increasing. The advantages accruing through the use of compound motors are:

A. The shunt field limits the top speed, thereby giving a more uniform speed regardless of load. A uniform top speed results in more uniform stopping on a dynamic brake.

B. A simplified control is provided, inasmuch as there is no need to provide separate excitation for the series field during the dynamic braking period.

When a compound motor is used, it is customary to provide an 80 per cent shunt field and a 20 per cent series field.

The hopper switch used for measuring the increments of travel of the distributor is a cam switch mounted in a weather-proof box, as shown in Figure 7. This is carried on needle roller bearings and driven by a flexible coupling through the gear unit on the distributor.

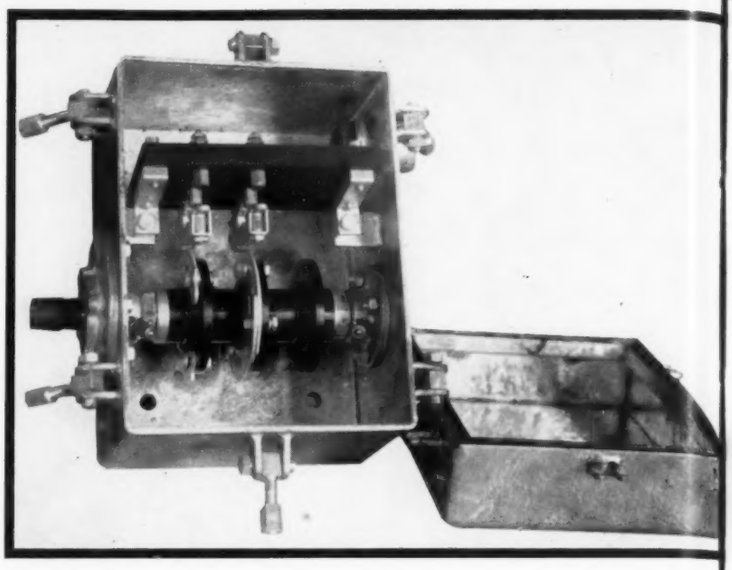


Figure 7 — Hopper limit switch for revolving distributor.

Automatic Measurement of Coke in Measuring Hoppers

In the modern blast furnace, coke is charged from central coke bins located adjacent to the skip pit, so that the coke may be charged directly from the bin into the skip car or into measuring hoppers. Many operators wish to provide screening of the coke just prior to its being charged into the skip car, and for this reason a vibrating screen is interposed between the central bin and the measuring hopper. Since the vibrating screen, or in some cases, stationary screen, slows up the charging of coke, the measuring hopper becomes very necessary in order to provide storage for the required amount of coke so that quick delivery to the skip car can be made when it comes into the pit.

In considering a coke charging installation, there is always the question whether feeders should be provided for feeding the coke to the vibrating screen. In our opinion, the only real function for a feeder is to prevent clogging of the coke in its discharge from the central bin and is not required insofar as the vibrating screen is concerned. If beehive coke is charged, the variation in size is quite large and there is a tendency to jam at the discharge from the central bin. A power-driven feeder of some description will alleviate this situation. With the usual run of by-product coke, the feeder is unnecessary. Of course, a manually adjusted regulating gate is required for limiting the speed of flow.

There are some operators who prefer to make this manually-regulated gate into an automatic shut-off gate, stopping the flow of coke to the screen when the measuring hopper is full. It has been said that this enables the screen to start more easily and prevents excessive wear on the screen cloth during the starting

Figure 8 — Automatic coke volume measuring equipment for measuring coke charged directly into skip car.

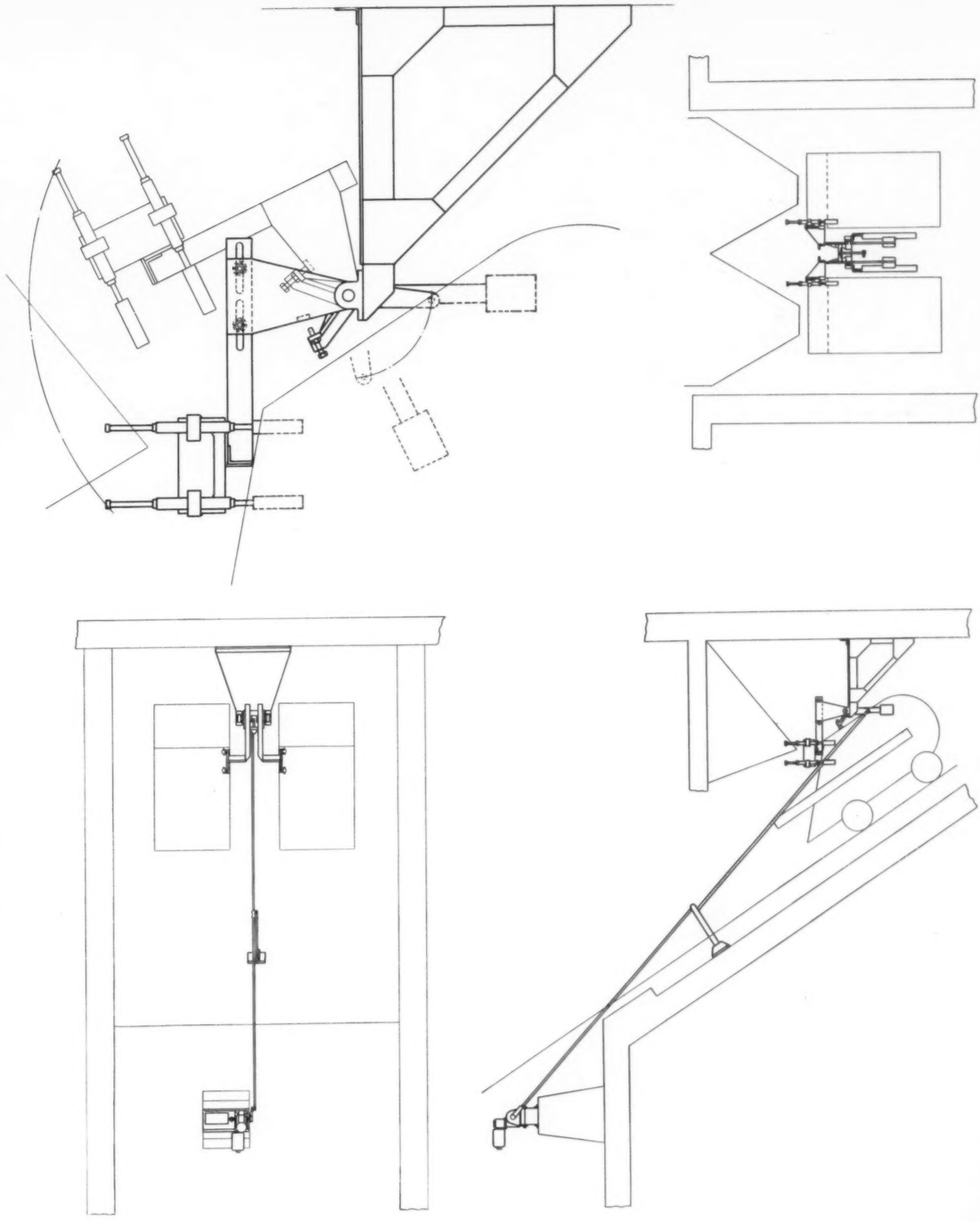


Figure 8 — Automatic coke volume measuring equipment for measuring coke charged directly into skip car.

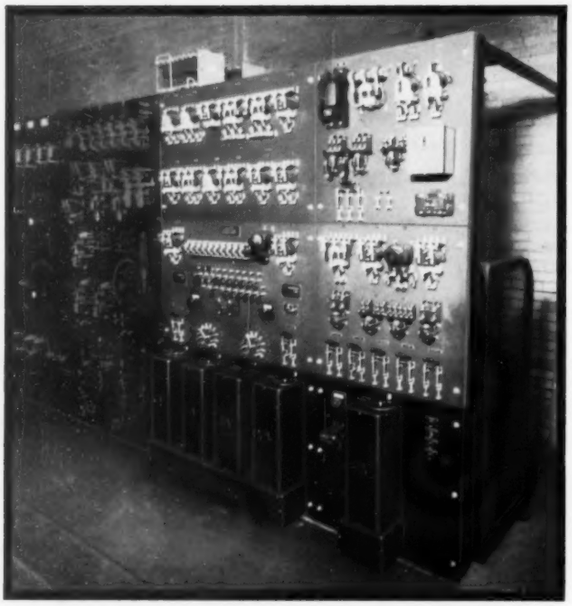


Figure 9 — Control panel for blast furnace charging control (at left) and automatic coke charging by volume directly in the skip tub (at right).

period. It is also said that better screening of the coke is obtained during the starting period, if the central coke bin gate is not opened until after the screen comes up to speed. We are inclined to believe that there is some point to the argument concerning excessive wear on the screen cloth and that a shut-off gate may possibly be justified on that basis. However, in nearly all of the installations we have made, there is no automatically-operated coke shut-off gate on the central bin. Shut-off of coke to the measuring hopper is obtained by stopping the screen. The modern vibrating screens start so quickly that it is quite possible that the point regarding wear of the screen cloth is starting in overstressed.

For screening coke, it has become almost standard practice to use a motor-driven screen, as opposed to a magnetically-operated or a stationary screen. In comparative installations which we have seen, the motor-driven screen appears to successfully screen more coke in a given space and time than the other types of screens.

In making the installations, the question comes up as to whether or not the screen should be floor-mounted, or hung from overhead. From the cost angle, the overhead mounting has the advantage. From the maintenance standpoint, particularly in changing screen cloth, the floor-mounted arrangement, especially if it is mounted on trucks, has a decided advantage.

Two very important factors bearing on the selection of screens that are to be used for measuring hoppers are, vibration and inertia. A screen and drive of low inertia should be used. This enables the screen to come up to speed very quickly, thereby starting efficient screening as promptly as possible. More important is the fact that a low inertia screen and drive will stop in approximately two to three seconds without the use of dynamic braking or shoe brakes. This is very important because the screen is used as a valve to control the shut-off of coke when the pre-determined weight or volume of coke is in the measuring hopper. The amount of over-run into the measuring hopper, depends entirely on how quickly the screen drops below the critical speed at which coke will be discharged from the screen cloth. With a low inertia screen, we have seen the over-run on a 3500 lb weight amount to less than 50 lb, while on a high inertia installation, we have seen the over-run amount to as much as 800 lb. The installation of dynamic braking of a high inertia job alleviated this situation, but did not make it as satisfactory as the low inertia screen.

Dynamic braking on a high inertia screen requires direct current power. This necessitates a higher priced motor and higher priced control and is subject to more maintenance. The low inertia screen is driven by a squirrel-cage alternating current motor which is the most rugged and reliable motor available. Some installations have been made of squirrel-cage motors on high inertia screens, with shoe brakes to aid in stopping the screen. It is difficult to maintain these brakes in good working order in the coke-laden atmosphere around the screens. The coke dust wears the linings excessively with the result that the braking power varies in accordance with the condition of the linings.

The question of vibration is an important one, particularly when scales are installed in connection with the weigh hoppers. We have seen installations where the scale supporting structure was tied into the same structure that supported the vibrating screens, with the result that we had vibrating scales, as well as vibrating screens. Accurate weighing is impossible under these circumstances and the maintenance on the scales becomes excessive. Needless to say, the only satisfactory way of operating scales on weigh hoppers, which are fed from vibrating screens, is to make sure that the supporting structures for the scales and weigh hoppers are entirely independent from that of the screens. This necessitates that the weigh hoppers and scale supports be independently mounted from ground level and not tied into the building structure.

The usual form of drive between the motor and the pulley of the vibrating screen is a V-belt drive. These, with which we have had experience, have proved very satisfactory.

Most measuring hoppers are equipped with scales so that the operator may weigh the amount of coke charged into the measuring hopper. Some kind of electrical contacts must be incorporated in the scale in order that the screen or shut-off gate may be closed when the required measurement has been secured. For this reason, it is well to investigate the beam ratio of the scale, i.e., the relationship between the actual weight in the weigh hopper and the weight required on the scale to balance it. A low beam ratio gives more power to operate the electric contact, i.e., the power required in operating the electrical contact at full weight has a lesser effect on the accuracy of measurement in a low beam ratio scale, as compared to one having high beam ratio.

There are several types of electrical contacts that can be used on the scales. One of those first used in the steel industry was an open-type contact with silver tips.

Naturally, this does not stand up in the atmosphere prevailing in the stock house, and excessive maintenance and burning of the contacts was the result.

A photo-electric type of contact mechanism, operated by a beam of light, is one that has been used. The difficulty here, however, is in the complicated control and mechanism required. The only installation of this type on coke weighing with which we are familiar, has been abandoned. In principle, it is good, but not for the heavy hands of a steel mill motor inspector. It has one advantage, in that no mechanical power is required of the scale beam in order to trip the contact. The magnetic mercury tube is being successfully used on many installations. The magnetic mercury switch is a switch in which the contact is attracted by a tiny magnet carried by the scale pointer. The contacts are entirely enclosed in glass and are actuated by the magnet outside of the glass. As long as the path of the magnet is kept close to the tube as the pointer passes by, very good results will be obtained. There is a small magnetic attraction between the magnet and the armature within the tube which affects the accuracy of weighing. However, this amounts to on the order of only 25 lb on a scale having a relatively high beam ratio.

The commonest form of electric contact in the scale is the tilting mercury type. In this construction, the scale pointer actually tilts the mercury tube when the required weight is reached. A small amount of power is required of the scale pointer in accomplishing this result. However, with a low beam ratio on the scale, the accuracy of weighing is fully equal to that of the magnetic mercury tube just described.

The design of a weigh hopper should be comparatively simple. The factors affecting the design are the following.

The slope of the bottom and sides of the hopper should be such that the coke will slide out easily and quickly. The average installation requires about fifteen or twenty seconds to load the skip car and sluggish discharge of coke increases this time and often leaves some coke remaining in the weigh hopper. A little attention paid to a good design of weigh hopper from the standpoint of getting the coke out of the hopper is the easiest way to save on the charging time in the filling of the furnace. Attention should be paid to corners and sloping edges where the sides meet the bottom slope. It is often desirable to cover these corners and sloping edges so that the interior has no obstructions or 90 degree corners to slow up the discharge.

Some measuring hoppers are bricklined to cut down the abrasion and wear of the steel plates forming the hopper. Coke does not discharge over brick nearly as rapidly as it does over steel. We much prefer the use of manganese wearing plates to a brick lining.

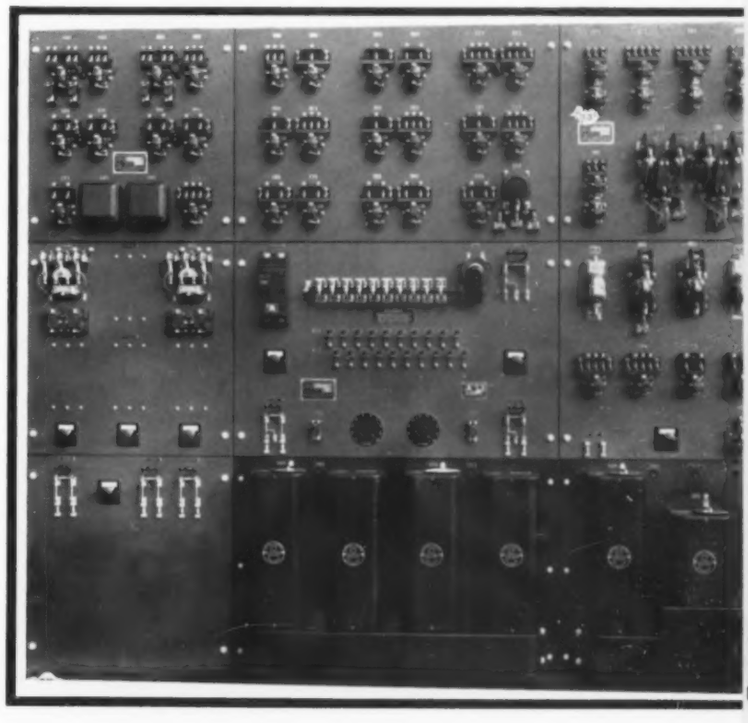
There are several forms of measuring hopper gates. In choosing the type of gate, it should be remembered that the gate is closed only when the measuring hopper is empty. For this reason, it is unnecessary to install a rotary gate, such as is used on central coke bins. The usual form of gate is a slide gate moving vertically, although some operators prefer a folding chute in which the chute is hinged on the bottom of the weigh hopper and folds back against the hopper to prevent coke from discharging. The folding chute discharges the coke at the desired point in the skip car. However, it requires more clearance between the skip car and the weigh hopper when in the retracted position. There is also the problem of positively interlocking the chute with the skip hoist so that, under no conditions, can the skip hoist tear the chute off from the side of the weigh hopper.

Another type of gate is a damper which is hinged at the top and swung out to permit the discharge of coke. We have used all types of gates, but the slide gate appeals most to us because of its compact arrangement, low cost and positive action.

For operating the measuring hopper gate, we have the choice of steam cylinders, air cylinders, or motor-driven operators. We have used steam cylinders and found them satisfactory except that they are sluggish, due to condensation in the steam cylinders during the waiting period. We much prefer the compressed air or motor-driven operator. There is some danger of freezing when compressed air (90 lb air) is used, and in such instances, we have used steam-heated air pre-heaters on the compressed air supply. The air cylinder and solenoid valve that go with it are of lower cost than any other type of installation.

However, we have adapted a motor-driven mechanism which has met with considerable favor even though it is of slightly higher cost. The motor-driven mechanism is used principally on the slide-type of hopper gate. It comprises a squirrel-cage motor-driven gear unit, on the low-speed shaft of which is mounted a drum equipped with slip shoes. Holding the slip shoes in place

Figure 10 — Furnace charging control equipment, showing blast furnace charging control on center panel, distributor control on right panel and automatic coke charging control on left panel.



on the drum is a single-wrap of cable, one end of which goes to the slide gate, and the other end to a counterweight. The principle of operation is one wherein the motor-driven operator lifts the gate and lowers the counterweight until the counterweight hits a stop, thereby stopping the gate and causing the shoes to slip on the drum until the motor is stopped. The reverse action applies when the gate is closed. This type of operator does away with the need of accurate stopping of the motor and, in addition, makes it impossible to break anything from over-travel of the motor.

The measurement of coke in the measuring hopper may be made either by weight, or by volume. When the measurement is made by weight, the screen is started as soon as the measuring hopper gate closes and runs until the full-weight contact in the scale opens a circuit on the screen motor control. Weight measurement gives the advantage of constant weight of carbon, provided the moisture content does not vary widely. If beehive coke is being charged, in which the size varies considerably, weight measurement is said to give a more accurate measurement of carbon than any other method.

However, if the moisture content is subject to considerable variation, volume measurement is claimed by many operators to give a more accurate account of the carbon content in the coke. Some operators compromise by charging half of the coke by volume and the other half by weight.

As you can see from the foregoing, the subject is a controversial one and we have taken care of it by providing equipment that can measure either by weight or by volume, depending entirely upon the operator's preference. Should he so desire, he may charge coke through one measuring hopper by weight, while at the same time he can charge through the other measuring hopper by volume. This is accomplished by means of a transfer switch for each weigh hopper which enables the measuring hopper to either be filled by weight or by volume.

Volume measurement is obtained by means of an electrode hung from the side of the weigh hopper. The height and position of the electrode is fixed to give the desired volume of coke. The electrode is of special design so as to make good contact with the coke. It is energized by the six-volt secondary circuit of an induction relay. When coke touches the electrode, it shorts the secondary coil of the induction relay causing the relay to operate and stop the screen. Coke is an excellent conductor of electricity. It acts like a pool of mercury insofar as making an electrical circuit is concerned. Inasmuch as the voltage is low, there is no danger of shock from the electrode. Also, since this low voltage is obtained from a small transformer, it does not ground the plant power supply. The volume method of measurement has proved so accurate and reliable, that it is used as a back-up for the scales when weight measurement is used. The electrodes are set at a volume that will be slightly higher than that given by the desired weight of coke. In the event of a scale failure, the electrode will shut off the screens before a coke spill occurs.

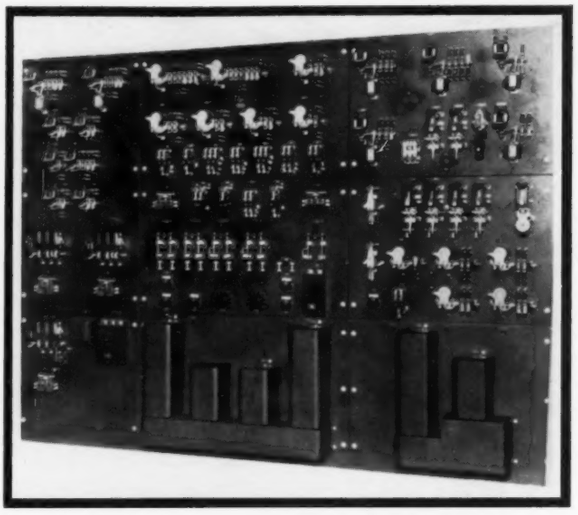


Figure 11 — Furnace charging control equipment, showing blast furnace charging control on center panel, distributor control (at right) and automatic coke charging (at left).

Automatic Measurement by Volume in Skip Car

Coke cannot be screened as rapidly as it can be charged into the skip car. Hence, if the coke is to be screened, it is necessary to provide a storage hopper and fill it, while the skip is handling other materials. Then, when it is time to charge coke, there will be a measuring hopper full of coke which may be discharged quickly into the skip car.

Some operators who obtain their coke from a coke plant adjacent to the blast furnace, do not feel that the coke needs to be screened, inasmuch as it is screened at the coke plant and not subjected to much handling between the screening at the coke plant and delivery at the central coke bin. If, in addition, the operator is not interested in weighing the coke, there is no reason for providing the storage hopper. Coke could be discharged directly from the central coke bin into the skip car. It is only necessary to provide an automatic means for controlling this discharge of coke into the skip car. Our automatic coke volume measuring equipment was designed with this in view.

The coke volume measuring device is essentially a system using an electrode similar to that used on the measuring hopper. In this instance, however, it is necessary that the electrode be lowered into the skip tub.

This is accomplished by locating a line shaft adjacent to the skip cars, as shown in Figure 8. On this line shaft are mounted two electrode arms which are, in turn, operated by cranks which are keyed to the line shaft. The electrode arms are not keyed to the shaft but can be rotated around the shaft under the control of the cranks which are keyed to the shaft. The motor-driven operator may be located in the skip pit if desired, but usually is placed at a more convenient location as shown in the diagram.

Both electrode arms normally stand in the raised position clear of the skip car. When it is desired to

charge coke, the motor-driven operator turns a half revolution lowering the two electrode arms which are resting on their respective cranks. One of the electrode arms will be lowered into the skip car that is in the pit and rest the arm on the side of the skip car. The other electrode arm will hang in the empty pit. The motor-driven operator is stopped by a cam switch connected thereto after it has made a half revolution. Inasmuch as the electrode arm simply rests on its supporting crank, it is possible for the supporting crank to continue rotation after the electrode arm stops on the side of the skip car. This arrangement makes it unnecessary that the skip car be stopped each time at exactly the same relative location in the pit.

The method of securing a coke charge is as follows:

We have previously referred to the small bell program on the charging control which controls the operations of the skip and small bell. Loading the skip is a definite point in the sequence of filling and we can, therefore, add two more points or notches on the small bell program and obtain the desired sequence. With such an arrangement, when a coke charge is called for, the small bell program on the charging control will not go from Position I to Position II, as previously described, but rather from Position I to Position IB. If coke were not to be charged, the small bell program would turn through Position IB and Position IC directly to Position II, and the normal events would take place. However, in this instance, coke is to be charged so that the small bell program turns to Position IB.

Position IB — Position IB causes three things to happen:

A. The skip hoist control is disconnected, making it impossible for the skip hoist to operate.

B. The electrode operator is started, causing the electrodes to be lowered into the skip car.

C. When the electrodes are in position over the skip car, as indicated by the contact closing in the cam switch on the electrode operator, and have been energized with power, the small bell program moves to Position IC.

Position IC — Position IC causes three events:

A. The central coke bin gate opens and discharges coke into the skip car. The central coke bin gate is generally air-operated, inasmuch as it will be necessary for the gate to cut through the coke and shut off the flow when the skip car is full.

B. When the coke touches the electrodes, a circuit is completed, actuating the induction relay, previously referred to, which in turn causes the coke gate to be closed and the electrodes rotated out of the skip car.

C. When the electrode operator has made its second half revolution and pulled the electrodes into their raised position clear of the skip car, a circuit will be completed in the electrode operator cam switch which will cause the small bell program to move from Position IC to Position II. In Position II, the normal sequence of operations is initiated on the charging control. In this position, it will be recalled that a check is made to insure that the distributor operation is completed, after which the program moves to Position III and starts the skip and small bell operation.

The advantage of this method of coke measurement are:

A. Faster loading of coke is obtained than by any other method.

B. More accurate measurement of coke is obtained than if an operator were working the central coke bin gate, due to the fact that the operator cannot always see on account of dust, and generally has to fill the skip car partially full and then inch the gate to fill the car full.

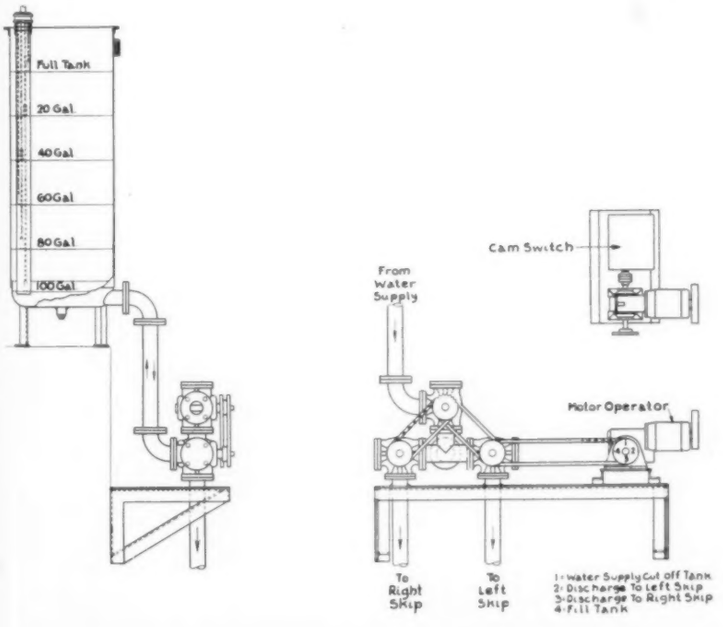
C. The equipment can be placed in practically any skip pit without change to the existing layout. Although a certain amount of space is required for the electrodes and line shaft, we have to date found no place at which such space was not available.

D. It is much lower in initial cost than any other automatic coke charging arrangement, inasmuch as there are no screens, conveyors, weigh hoppers, scales and the like to be purchased.

E. This method of measuring coke may be combined into an automatic coke charging system so that the coke is automatically charged without the attendance of an operator.

There are now three installations of this equipment giving satisfactory service. One installation has had two years' of service, and a second installation has had a year of service. The plant purchasing the second installation has now purchased a duplicate installation

Figure 12 — Sketch showing arrangement of stock watering equipment.



for its new blast furnace plant now under construction. A third plant has made an installation recently and is now contemplating three additional installations.

Automatic and Pre-set Charging of Coke

In the foregoing, we have shown how coke can be automatically measured into measuring hoppers either by weight, or by volume, or directly in the skip car. There remains to provide means for automatically charging the coke into the skip car at the proper points in the round, even though the scale car operator is not present to supervise this charging. This enables the scale car operator to get ore or stone loads in the scale car while coke is being charged. The function of the automatic control is to:

A. Select the skips to be filled with coke.
B. Load the desired skip with coke after it arrives in the pit.
C. After the loading is completed, to automatically send the skip on its way to the top of the furnace.

We have two methods of accomplishing this result, one known as the pre-set type of skip selection, and the other, the automatic type.

In the pre-set type of coke charging, there are two pre-set push-buttons, together with the pre-set relays and signal lights. When the operator places the last load into the skip car prior to a coke charge, he starts the skip by pushing the skip-start push-button and then pushing one or two pre-set push-buttons, depending on whether he desires one or two coke charges to be made, while he is away loading the scale car. When he pushes the pre-set push-buttons, signal lights will light and show that the coke charges desired have been pre-set. These lights will remain lighted until the desired charges have been completed.

The limitation of the pre-set type of charging is that it can only be set for a maximum of two consecutive skip loads.

In the full automatic type of coke charging, there are provided coke selector switches which may be closed to cause the charging of coke at any desired points in the charging round. These coke selector switches are energized successively by contacts in the counting program. Inasmuch as the counting program ordinarily furnished on the charging control does not have sufficient contacts to accomplish this result, we add another cam switch and drive it from the same motor that is used for driving the counting program. This counting program, which actually counts the dumps of the small bell, can be used to set up circuits to determine the skip charges by closing coke selector switches which are in series with contacts on the counting program. We can automatically select the skips in the round in which we wish to charge coke. With this type of coke charging, there is no limitation on the number of coke charges that can be automatically charged. In fact, if the coke selector switches are so set, all skips can be filled with coke.

Each method has its own advantages and disadvantages. The pre-set arrangement is lower in initial cost and uses less equipment. The automatic method requires selector switches and an additional cam switch. The pre-set type is more flexible in that the operator can change the order of coke charges without the need of re-setting the selector switches. Some operators think that this is a disadvantage, as the full automatic type prevents the skip operator from forgetting to set up a coke charge. The pre-set type has the limitation of two consecutive loads, while the automatic method has no limitation on consecutive loads.

Regardless of which method is used, a relay or relays will be closed when a coke charge is to be initiated. In the case of the pre-set type of charging, two pre-set relays, known as left coke charge relay and right coke charge relay, will have been closed if two coke charges are to be initiated. In the case of the full automatic charging, a coke charging relay will have been closed because the combination of coke selector switches and counting program are calling for a coke charge.

As previously explained, a coke charge is a definite event in the sequence applying to the small bell program, i.e., it is an event that can be sequenced by the small bell program. This is done by adding one point or notch in the schedule of events normally called for on this program. When an ore charge is to be initiated, the small bell program turns directly from Position I to Position II. If, however, a coke charge is to be initiated, the small bell program will turn from Position I to Position IB. On an ore charge, Position IB is a dead

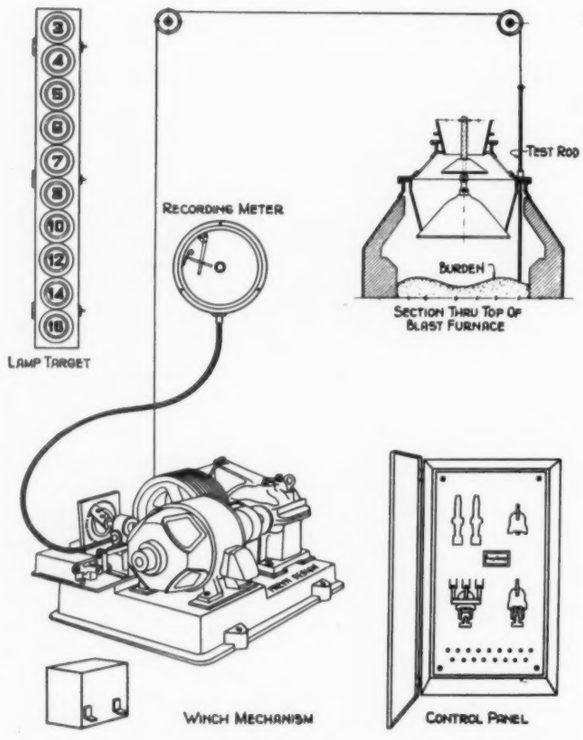


Figure 13 — Schematic arrangement of automatic stockline recorder.

point, but when coke is being charged, it is a live point through the action of the coke charge relays. To get from Position I to Position IB, it is necessary that the skip has arrived in the pit and that the control call for a coke charge. In addition, it is necessary that there be full measure of coke in the measuring hopper. Otherwise, the small bell program is held in Position I until the required measurement is secured, whereupon the cycle automatically resumes.

Position IB — Three events take place in this position:

A. The measuring hopper gate is opened by means of its operator, permitting coke to discharge into the skip car.

B. When the scale on the measuring hopper indicates zero weight, a contact on the scale is closed which actuates the control to cause the measuring hopper gate to close.

C. When the gate is actually closed, as determined by an interlocking switch on the gate, a circuit is completed which causes the small bell program to move from Position IB to Position II, where the normal cycle of events on the furnace equipment resumes. At this point, the vibrating screen is started to refill the measuring hopper. The screen can run in all positions of the small bell program, except Position IB, which is the point at which coke is to be charged into the skip car.

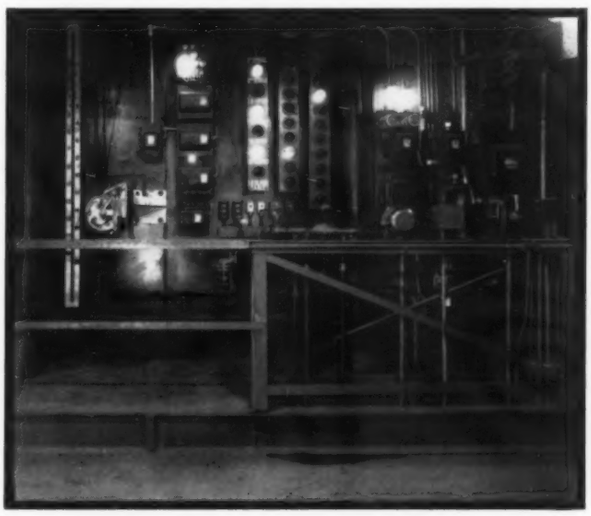


Figure 14 — Obsolete version of a master panel.

If coke is to be charged by volume directly into the skip car by rotating electrodes into the skip car, as previously described, the action is similar to the above, except for the fact that two points are provided on the small bell program, namely, points IB and IC. The charging is instigated either by the coke charging relay if automatic coke charging is to be used, or by the pre-set relays, if the pre-set type of coke charging is to be used.

Provided a coke charge is called for and the skip is in the pit, the small bell program will automatically turn from Position I to Position IB.

Position IB — In this position, the electrodes are rotated into position in the skip car and energized. When these actions are completed, as indicated bythe closure of a contact in the electrode operator cam switch, the small bell program moves from Position IB to Position IC.

Position IC — In this position, the gate on the central bin discharging into the skip that is in the pit is opened automatically by its operator discharging coke into the skip car. When the car has been sufficiently filled with coke to complete a circuit on the electrodes, the electrode relay is actuated resulting in the closure of the bin gate and the retraction of the electrodes. When the electrodes had been raised to their uppermost position, as determined by the cam switch on the electrode operator, and provided the bin gate is fully closed, as indicated by an interlocking switch placed on the bin gate, the small bell program moves from Position IC to Position II where the normal cycle of events on the furnace filling resumes.

We wish to again point out that this charging of coke by volume in the skip car can be controlled either by the automatic method in which any number of skip-loads of coke can follow each other consecutively or at any desired points in the round, or by the pre-set method of controlling.

Scale Car Interlock

By scale car interlocking we refer to equipment that will prevent opening of the scale car hopper gates until certain conditions have been fulfilled. It consists of two magnetic latches which lock the handles of the air valves controlling the opening of the scale car hopper gates, and which are electrically controlled through two collector shoes mounted on the scale car. These shoes will contact two short sections of rail which are located at the unloading position of the scale car at the pit. The magnetic latch for a given scale car hopper will not be released until the following conditions are met:

1. The skip car is at final stop in the pit.
2. The scale car hopper, which it is desired to open, is spotted over the skip car that is in the pit.
3. A coke charge is not called for by the coke charging control.

This arrangement makes it impossible to:

A. Discharge material from the scale car when the skip is not in place to receive it.

B. Place materials other than coke into a skip car which is to be filled with coke or which has been filled with coke and has not yet left the pit.

Stock Watering Device

The Freyn-Design stock watering equipment is a device by means of which the amount of water charged into the skip car is accurately measured in a tank and charged to the skip car by remote control, i.e., through the manipulation of a push-button switch. The amount of water to be charged may be selected by manipulating a five-point dial switch which selects one of five different quantities which ordinarily would be 20 gal, 40 gal, 60 gal, 80 gal, or 100 gal, although by changing the

electrode lengths any other five sets of water quantities can be obtained. The flow of water into the tank and out of the tank into each of the two skip cars is determined by the position of three three-way cylindrical plug valves, which are in turn driven by a motor-driven operator under the control of a cam switch. The operation of charging water is entirely automatic. The charging of water is initiated by the manipulation of a push-button switch, the plug valves being opened and closed to charge the pre-determined amount of water and to also again fill the tank after the proper quantity of water has been discharged.

In front of the scale car or skip operator are a push-button switch and a dial selector switch. The operator will set the dial selector switch to give the required water quantity. To initiate a water charge, the push-button switch is manipulated. Provided the water tank is full, the manipulation of the push-button switch

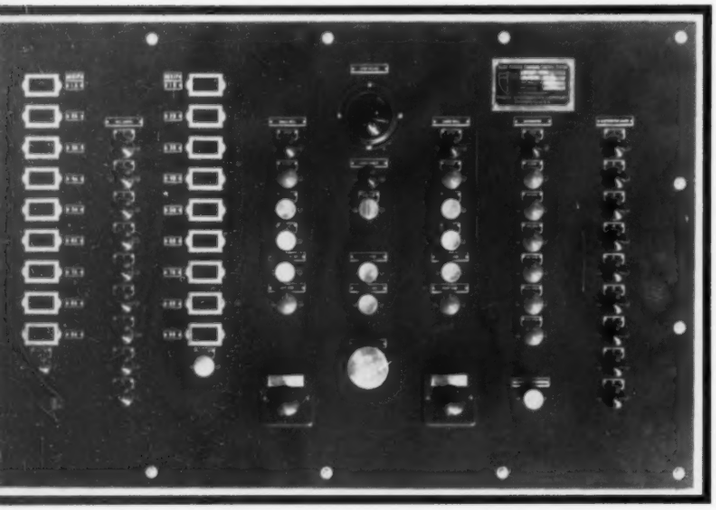


Figure 15 — Master panel for a blast furnace charging control, distributor control and automatic stockline recorder.

closes the water charge contactor and lights a signal light which remains lighted until the desired quantity of water has been placed in the skip. As soon as a skip car arrives in the pit, a contact in the skip hoist limit switch closes, which selects the proper contactor in the control to cause the valve operator to turn the three-way plug valves to such a position as to cause water to be discharged into the skip car that is in place in the pit.

When the water in the tank recedes to a level that takes it out of contact with the electrode (which has been previously selected by the dial switch to give the required quantity of water), an induction relay in the control operates so as to cause the motor operator to again rotate the plug valves in such a manner as to cut the water supply off the skip tub and connect the tank to the water supply. The signal light then goes out, indicating completion of the water charge.

When the tank is full of water and comes in contact with the electrode determining a full tank, the induction relay again operates to cause the valve operator to rotate the plug valves so as to cut off the water supply to the tank.

In this connection, it may be stated that there are three three-way two-port plug valves, each of which is arranged to stop at four angular positions. One of these cocks controls the water supply to the tank. A second valve controls the water discharge from the tank to the right skip. The third plug valve controls the water discharge from the tank to the left skip. The four angular positions of the plug cocks, which, by the way, are all driven by the same motor-driven operator, are as follows: 0 degrees, water flows from plant supply to tank; plus 90 degrees, water supply from plant system is shut off from tank; plus 180 degrees, water is discharged from tank to right skip; minus 90 degrees, water is discharged from tank to left skip.

It will be noted that each time water is discharged, it is under the control of an induction relay which in turn is operated by two electrodes, one electrode determining a full tank and the second electrode determining the level to which the water is discharged from the tank. Inasmuch as there are five different electrodes for determining the levels to which the tank is to be emptied, there are, of course, five different quantities of water which will be discharged, depending upon the setting of the dial selector switch.

From the foregoing description, it will also be noted that the operation is entirely automatic from the time it is initiated by the manipulation of the push-button switch. The valve operator positions the valves under the control of the cam switch (which it drives) and the induction relay, together with the water charging relay and reversing contactors.

Breeze Hoist Control

There are many ways of taking breeze out of the breeze collector under the vibrating screens, but the commonest arrangement is to provide a separate breeze hoist for each collector, this hoist being a small automatically-operated skip hoist. There is considerable variation in weight and amount of breeze collected per round. This makes the automatic starting of the hoist difficult. Methods used in the past include:

A. Tripping a counterweight on the breeze hoist when a sufficient weight of breeze accumulates in the car. It is difficult to adjust the tripping point to keep the car from over- or under-filling.

B. Starting the hoist automatically whenever the large bell dumps. This usually runs the hoist more often than actually required. If there is more than the usual amount of breeze in the coke, or if the number of coke charges per round is increased, the car over-fills.

For automatic starting of the breeze hoist, we place electrodes on the breeze chute which extends from the breeze collector into the car. When the breeze reaches the electrode, a circuit is completed to an induction relay just as in the case of the stock watering device and the coke volume measuring device previously described. This starts the hoist. The breeze car, in leaving the pit, pulls the breeze chute (and electrodes mounted on it) out of the way of the car. This movement of the chute cuts off the flow of breeze until the car returns to the pit, when the chute and electrode will again be lowered into the car.

This arrangement gives us correct filling of the car and the hoist is run no more than actually necessary

Automatic Stockline Recorder

The automatic stockline recorder, to which reference has been made several times in this discussion, comprises a test rod which rests on top of the burden in the blast furnace, and is carried on a cable which is controlled by means of a motor-driven winch. The motor on the winch mechanism is connected across the line in series with resistance so that it is tending to pull the rod out of the furnace at all times. However, the torque developed by the motor is less than the pull of the test rod so that the weight of the test rod overhauls the motor and follows the burden as it moves downward in the furnace.

Geared to the drum of the winch mechanism is a position switch which indicates the test rod has moved below the index or bottom of the large bell when closed. This position switch lights lamps which indicate the depth which the test rod has reached. The position switch also drives a recording meter in which a pen moves across a calibrated chart and records the test rod position. The recording meter may be driven by a flexible drive shaft as shown in Figure 13, or may be operated by remote control through the use of selsyn or autosyn self-synchronous transmitting devices.

When it is time for the large bell to be opened, it is necessary that the test rod is hoisted to its uppermost position by short-circuiting the resistance in series with the motor, with the result that the torque of the motor is sufficient to rapidly hoist the rod.

After the large bell operation has been completed, the test rod is again lowered to the burden. A counter-voltage relay limits the lowering speed by short-circuiting a part of the resistors in series with the motor. It will be remembered that it is the weight of the test rod that causes it to be lowered against the existing torque of the motor, which, at all times, is endeavoring to raise the test rod.

The method of operation we have described is a so-called continuous-type in which the test rod rides the stock. This is the preferred method of operation since the continuous-type of machine was introduced some ten years ago. There are some operators, however, that prefer an intermittent-type of operation in which the test rod is lowered to the burden and then immediately withdrawn, after touching the burden level. This type of operation is accomplished by turning a transfer switch from continuous to intermittent. In this way, we are able to secure two types of operation on the same machine.

There are some operators who prefer an even different method of operation which is called the "step" type. We have built several machines of this description. In this case, the test rod is lowered to the burden and then the power is taken off the motor and the brake set, thereby holding the test rod motionless at this level. At the end of a pre-selected interval — let us say two minutes, the power is again applied to the motor and the brake released, with the result that the test rod again descends to the new burden level, after which the brake is again set. This cycle is repeated at two-minute intervals, until it is time to dump the large bell, when the test rod is withdrawn to the top of the furnace.

A stiff test rod or a semi-flexible test rod may be used with the automatic stockline recorder. A stiff test rod, of necessity, must be strong in order to withstand the stresses occurring on a slip or rolling of the burden. Use of a flexible test rod permits the use of a smaller diameter of rod and eliminates trouble that arises from bent test rods.

The flexible test rod comprises a special type of cable that will withstand the severe conditions of operating within the blast furnace. It is of circular section, so that it may be sealed at the point at which it extends through the furnace. A foot or weight is permanently attached to the bottom end of the cable. Inasmuch as the winch mechanism is continually exerting an upward pull on the test rod, the cable is held straight and unbent except when the furnace rolls. The test rod or flexible cable will be automatically straightened as soon as it is again withdrawn to dump the large bell. There are several installations of the semi-flexible test rod, all of which are operating successfully.

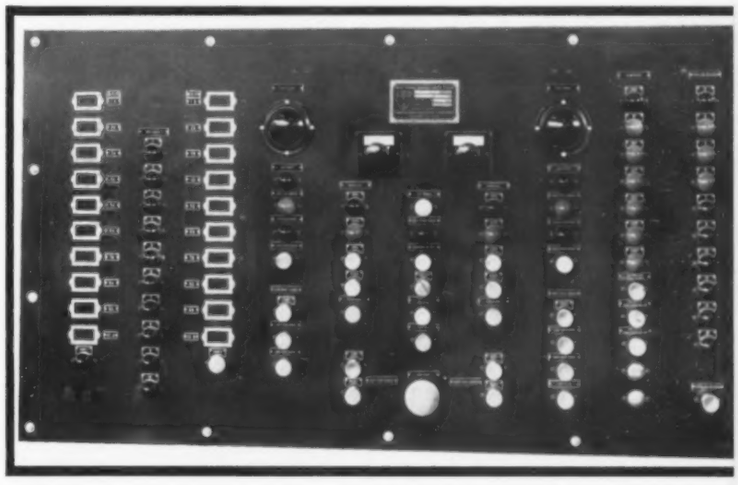


Figure 16 — Master panel for a blast furnace charging control, distributor control, automatic coke charging control and stockline recorder.

You will at once ask how we get the flexible test rod with a foot on the end of it into the furnace. A new test rod installation must be made with the furnace in operation. This operation can be accomplished on both the rigid test rods, as well as the semi-flexible rod without going inside of the furnace. Some operators have accomplished this without taking the wind off the furnace.

Master Panel

Inasmuch as there is no skip operator required on a modern blast furnace, and because the scale car operator is at the pit only at short intervals, it is necessary to provide signal lights, and control push-buttons by means

of which the scale car operator can ascertain what has happened while he has been away, and what is the status of the filling operations on his return. Figure 14 shows the arrangement of signal light push-buttons and other control devices, which was customary as late as 1938. This is a miscellaneous jumble of pipes, switches, and boxes, which are expensive to install and maintain, and from which it is hard for the scale car operator to visualize the operating conditions.

In 1938, we made our first installation of a master panel, one of which is shown in Figure 15. This master panel is used in connection with a blast furnace equipped with a furnace charging control, reversing distributor control, pneumatic bell hoist, and stockline recorder. The column of lamps at the extreme left indicates the number of dumps that have been made by the small bell.The column of lamps at the extreme right indicates. the stock level as determined by the stockline recorder. The column of lamps next to the stockline recorder lamps indicates the distributor position and whether or not it is running. The big lamp at the top center is the stop filling signal. The little lamp immediately beneath it indicates slack cable on the large bell. The two lamps on either side of the slack cable lamp indicate the open and closed position of the small bell and the large bell. Directly beneath these signal lamps are the push-buttons for manual control of the bells, for starting the skip, for making emergency stops on the skip, for obtaining extra loads, and for cutting short the charging round.

The master panel shown in Figure 16 is one that is used on a blast furnace which is equipped with a pneumatic bell hoist blast furnace charging control, reversing distributor control, stockline recorder and automatic charging and measuring of coke.

The events portrayed by the signal lights are:

1. When and which skip is in the pit.
2. Coke charge.
3. If a split round is being used, which half is being performed?
4. How many dumps lie on large bell?
5. What material is to be charged next?
6. How full is the furnace?
7. Is small bell open or closed?
8. Is large bell open or closed?
9. Has blower stopped the filling of the furnace?
10. Are the coke weigh hoppers filled to full measure?
11. Are weigh hoppers over-filled?
12. Has the slack cable device on large bell tripped?
13. Is a-c power available (coke electrode)?
14. Is skip protective relay tripped?
15. Is distributor running?
16. What angle is distributor to turn through?

In addition, there are some push-buttons provided for normal operation. These push-buttons are:

1. To start the skip on material loaded from the scale car.
2. To stop skip in an emergency.
3. To stop or cut out either or both vibrating screens.
4. To cut out automatic coke charging.
5. Extra load.
6. Extra coke.
7. Charging re-set — to cut round short.

There are times when, for inspection purposes or other reasons, it is desired to manually operate certain parts of the equipment. For this reason, transfer switches are provided so that all of the furnace filling equipment may be cut loose from the automatic control and operated individually under the control of push-buttons. These push-buttons and transfer switches are mounted on the master panel. Their functions are:

1. Transfer switch to put bell hoist on manual operation.
2. To open and close small bell.
3. To open and close large bell.
4. To open and close weigh hopper gates.
5. To operate vibrating screens.

This master panel is, in reality, a steel panel on which the signal lights and push-buttons are mounted. The push-buttons are provided with dust-tight operators. The panel forms the front of a steel cabinet having a removable back. This cabinet forms a pull box for the various conduits bringing in the wires connecting to the equipment. The panel is sealed in rubber so as to make it dust-tight. It is furnished wired to terminals to make connections from the outgoing loads with convenience. It greatly reduces the space requirement for this control equipment and cheapens its cost of installation. The size of the panel shown is approximately 4½ ft wide by 2½ ft high.

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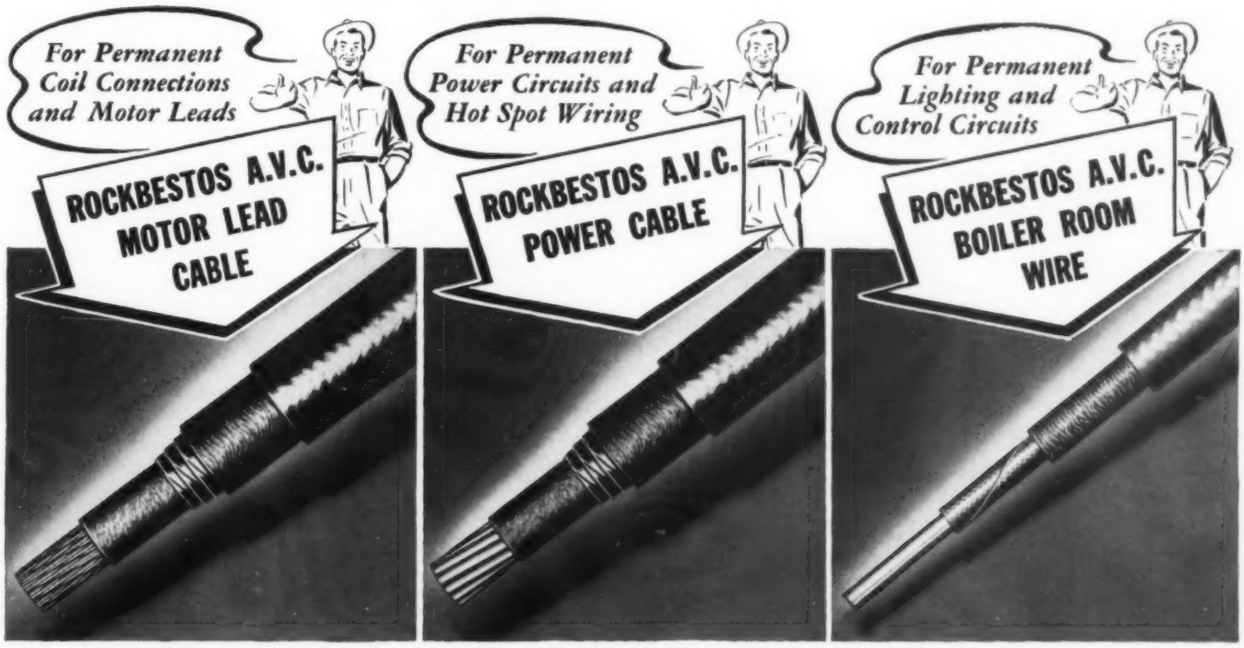
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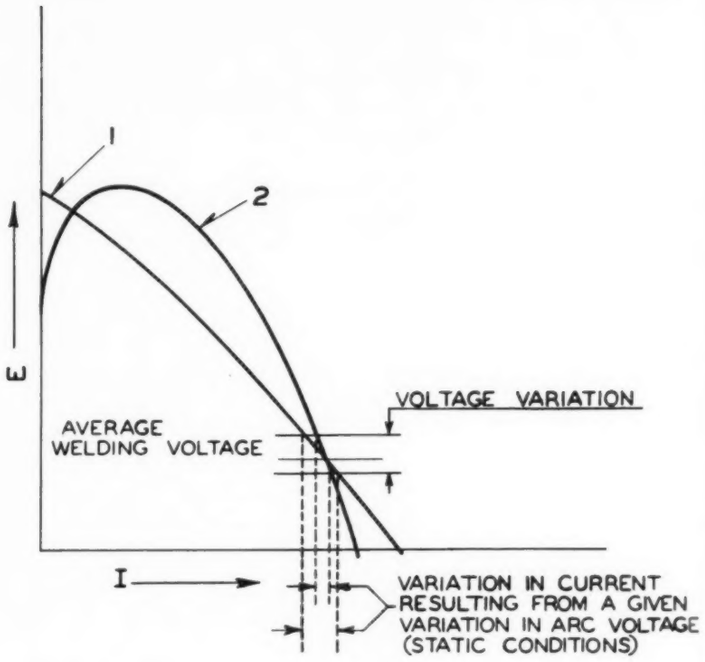


Figure 1 — Typical volt-ampere curves showing the effect of variations in slope.

▲ WELDING machines, like most types of equipment, are made in a great many varieties and designs. In addition to this, they are primarily tools used by welding operators, consequently their merits are based partly on an individual's judgment rather than entirely on electrical and mechanical standards. The selection of a welding machine, therefore, must be based on electrical, mechanical and economic factors such as initial cost, operating cost, efficiency, maintenance, obsolescence, space factor, etc., and upon weldability, such as ease of striking and holding an arc, usability under all welding conditions, arc blow, etc.

Arc welding machines can be classified into three general groups: d-c machines, a-c machines and rectifier machines. The d-c machines consist of a specially designed generator which is driven by an electric motor or a gasoline or diesel engine. The a-c machines are either a transformer or a motor-generator set, the motor of which may be operated with d-c or a-c. Rectifier machines obtain rectification by electronic tubes or oxide plates.

In addition to this general classification, both a-c and d-c machines may be grouped into single-operator and multiple-operator sets.

The welding engineer is often called upon to make recommendations regarding the type of welding machine to use or buy. Unfortunately the answer to this problem cannot be obtained by a standard rule or formula because the conditions surrounding each application are different. It is the purpose of this article to discuss the characteristics and merits of the different types of machines as an aid in selecting the proper equipment for each application.

Welding Machine Characteristics

There are certain electrical characteristics that are essential in a welding machine. It is not the present aim to outline how these characteristics are obtained through machine design, but to discuss what they are and why they are essential. Many articles have been written on welding machine characteristics and just as many different conclusions have been drawn regarding what is desirable. Unfortunately, many of these conclusions have been based upon a theoretical analysis of the problem rather than upon practical tests.

Some time ago the authors had occasion to test five machines, the characteristics of which were widely different, although based on theoretical analysis each machine could have been considered ideal according to requirements established by different theories. These machines were tested by 20 welding operators in such a manner that it was impossible for the operator to

know which machine he was using. The results of the tests are given in Table I.

TABLE I

Welding Operator Blindfold Test — Flat Position

Machine	Times rated best	Times rated poorest
No. 1	5	4
No. 2	4	2
No. 3	2	6
No. 4	4	4
No. 5	4	2

Two possible conclusions can be drawn from a test of this type:

1. Under the conditions of the test the electrical characteristics of the machine are not critical.
2. Weldability is a matter of personal judgment.

The second conclusion is worthy of further comment because it has an important bearing on the value of practical weldability tests.

During the "blindfold" test, each operator was asked what welding characteristics he considered desirable. The answers received were as follows:

1. A smooth, quiet arc.
2. A crackling arc, because it appears to give better penetration.
3. Ability of the machine to hold a long arc.
4. Ability to break the arc without drawing it out too long.
5. Amount of spatter produced.

Further investigation into the matter indicated that an operator's ideas on what welding characteristics were desirable were dependent largely on the characteristics of the machine he normally used in his work.

From the preceding comments it is apparent that although a welding operator's judgment is important, it cannot be used as an infallible guide of weldability because there are no recognized standards. Before a definite weldability rating can be given to welding machines, therefore, a standard must be established and a scientific method of checking whether or not a machine meets these standards must be developed. Considerable work has been done along these lines and automatic welding machines have been employed for checking weldability but at present the results are too meager to draw many definite conclusions.

Although the effect of electrical characteristics on weldability is not entirely known, there is certain fundamental information available.

During arc welding the electrical circuit is periodically shorted. This condition is obtained in several ways, such as by touching the electrode to the work in order to strike the arc, by accidently shorting out the arc, and by drops of metal from the electrode bridging the arc gap during transfer from the electrode to the work. Because of this fact it is essential that a drooping volt-ampere characteristic be used in order to limit the short circuit current. Two general types of volt-ampere characteristics, as shown in Figure 1, are used. Curve 1 represents a continuously drooping characteristic between maximum voltage at open circuit to maximum current at short circuit. Curve 2 represents a characteristic having a moderate open circuit voltage. As the load resistance decreases to short circuit value, the current increases and the voltage rises to a maximum and then falls rapidly.

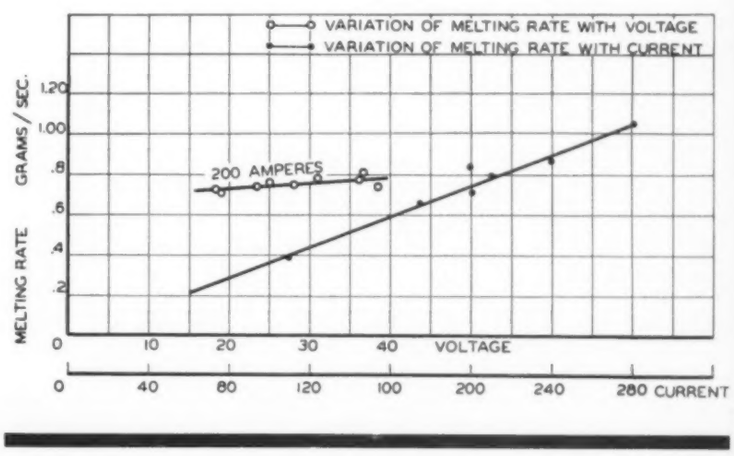
With manual welding it is impossible for the welding operator to hold a constant arc length. Varying the arc length causes the arc voltage to vary, which in turn produces corresponding changes in welding current. The steeper the volt-ampere curve, within the welding range, the lower the current change is for a given voltage change. This is illustrated in Figure 1. A steep characteristic produces small current changes for a given arc voltage change and a welding machine with this type of characteristic is generally known as a constant-current machine. A flat characteristic produces large current changes for a given change in arc voltage. If the slope of the characteristic is such that the product of current and voltage is approximately constant for a given machine setting, the machine is known as a constant-energy machine.

Tests made on electrodes indicate that under normal welding conditions the melting rate is directly proportional to the current and almost independent of the arc voltage. The curves shown in Figure 2 illustrate the effect of current and voltage on electrode melting rate.

In many welding operations it is desirable to maintain a constant current in order to obtain maximum welding speed and quality, consequently in such cases a steep volt-ampere characteristic is desirable. In other cases a flat volt-ampere characteristic might be desirable so that the operator can occasionally control the welding current within small limits by lengthening or shortening the arc. It is probable, therefore, that the conditions surrounding the welding operation determine the type of volt-ampere characteristic that is most suitable.

The average arc voltage maintained during welding may vary between 15 and 50 volts, depending upon the welding process. In addition to this, occasional magnetic disturbances may cause the arc stream to elongate or loop, thereby increasing the arc length and arc voltage

Figure 2 — Effect of current and voltage on melting rate of electrodes



considerably above the average value. In order to maintain an arc, therefore, it is important that the available impressed voltage, neglecting transients, be higher than the voltages that might be obtained during the welding operation. When welding with a machine having a characteristic of the type shown by curve 1, Figure 1, it is essential that the open circuit voltage be above the maximum voltage obtained during welding. When welding with a machine having a characteristic of the type shown by curve 2, Figure 1, it is essential that the maximum voltage value be greater than the maximum voltage obtained during welding. Tests on the maximum voltages that can be obtained with a carbon electrode for a given machine characteristic (direct current) are given in Table II. Electrodes 3/8 in. in diameter were used and the welding machines were set to deliver 160 amperes at 18 volts.

TABLE II

Machine number	Open circuit voltage	Type of characteristic (Figure 1)	Maximum arc voltage
1	63	Curve 1	44
2	100	Curve 1	65
3	42	Curve 2	66
4	38	Curve 2	52
5	25	Curve 2	40

There is some question regarding the effect of open circuit voltage on the ease of striking an arc. The open circuit voltage of an arc welding machine is not high enough to automatically establish the arc, consequently the arc must be struck by first touching the electrode to the work and then withdrawing it. If an appreciable time is taken in this operation, the actual establishment of the arc starts from short circuit conditions and not from open circuit conditions.

If the base material is covered with an insulating foreign material, the difference in open circuit voltages normally used on welding machines will probably have no effect unless the foreign material is extremely thin, so that its resistnace will be broken down. If, however, the base material is covered with a moderately high resistance foreign material the current flowing at the instant of contact will be proportional to the open circuit voltage. Higher currents produce greater amounts of ionization, which in turn assist in establishing the arc.

In the major portion of all cases, however, it is believed that the act of striking the arc breaks through the foreign surface impurities so that small points of clean metal are exposed.

The actual operation of welding with metallic electrode consists of a series of short circuits resulting from drops of molten metal transferring from the electrode to the work. The frequency of these short circuits depends upon many factors, such as type of electrode, welding current, position of welding, etc., and varies from 6 to 40 or more per second. The time required to complete the transfer of a drop of weld metal will vary but under normal conditions seldom exceeds 1/40 sec. A typical oscillogram taken during welding is shown in Figure 3.

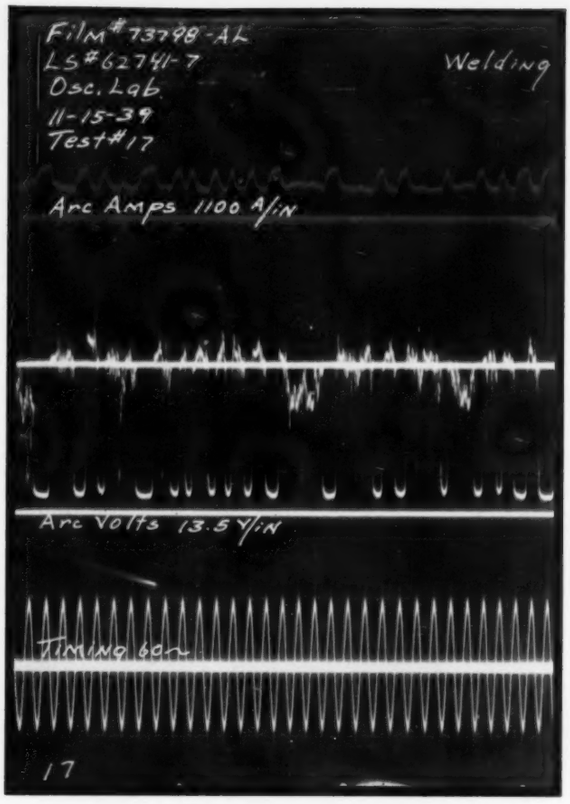


Figure 3 — Welding oscillogram taken on d-c machine.

The electric arc has, essentially, a constant voltage characteristic and the voltage changes resulting from changes in arc length occur instantaneously. The current output of a generator, for a given setting, is determined by the arc voltage and, for sudden changes, lags the voltage in reaching a steady state value. This means that the volt-ampere characteristics of the generator during periods of metal transfer do not follow the static curves shown in Figure 1. The actual volt-ampere characteristic is more nearly represented by the rectangular loop shown in Figure 4.

For the purpose of analysis it is assumed that the static volt-ampere characteristic as shown in Figure 4 is adjusted to deliver 130 amperes at 20 volts. These values represent the average welding current and voltage. The instantaneous voltage during arcing and short circuit periods vary from line 1-5 to line 2-3 respectively (Figure 4). The instantaneous current values under similar conditions may vary from points 1 to 3 or 6 to 4, depending on the welding machine and circuit conditions. At the instant a drop of metal produces a short circuit during welding the voltage falls from point 1 to zero (neglecting the voltage drop in the line) point 2. If the short circuit is maintained until steady state conditions are reached, the current will increase to short circuit value (point 3). In some cases it may increase beyond point 3 and overshoot to some value as represented by point 4 from which it will decrease again to point 3, short circuit value. The amount of overshoot,

if any is obtained, and the time required for the current to reach a steady state, is dependent upon the characteristics of the welding machine and welding circuit.

At the instant the arc is re-established the voltage will rise to point 5, following which the current will decrease to point 1 and possibly undershoot to some point 6, after which it will again increase to the steady condition, point 1.

During actual welding conditions the frequency at which short circuits occur and the length of time they last vary, consequently steady state conditions are not always reached at short circuit or arc voltages. The effect of these variations is essentially to shift or change the area within the rectangle shown in Figure 4. Whether or not these changes have any great influence on the quality of welding is not clearly known.

Two facts are known, however; extremely high overshoot currents as represented by point 4 have a tendency to increase spatter loss and low undershoot currents as represented by point 6 may cause the arc to become extinguished under certain conditions.

Constant potential and a-c welding machines have no overshoot or undershoot, consequently the transient volt-ampere characteristic would be represented by rectangle 1-2-3-5-1. Variable voltage machines generally have some overshoot and undershoot. The actual magnitudes may be small or very large, depending upon the design of the machine.

Direct-Current Machines

Direct-current welding generators are the most widely used type of welding machine in the United States at the present time, although a-c machines are becoming more popular. The problem of obtaining satisfactory electrical characteristics, as discussed in the previous section, is primarily a matter of design; consequently, that phase of the problem will not be covered in the following comparison of a-c machines.

Single operator machines — Single operator machines, as the name implies, are designed to deliver power to only one welding operator. The welding generators are generally of three types: (1) separately excited differentially compounded, (2) third brush excited differentially compounded, and (3) cross-field type machines. The methods of control vary with the type and design of the machine. The separately excited differentially compounded type machines generally contain a shunt field or a combination shunt and series field control. The third brush excited differentially compounded type machine is controlled by shifting the brushes or by a combination shunt and series field control. The cross-field type machines accomplish current control by varying the leakage flux between the main poles and by inserting resistance in the short circuited brush circuits.

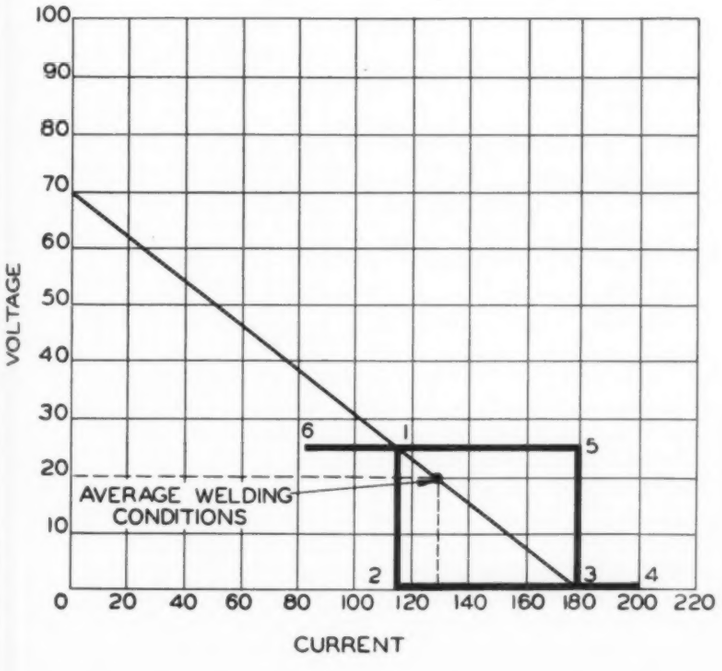
The essential differences between the different methods of control are as follows:

1. Shunt field control varies the open circuit voltage of the generator and produces a series of more or less parallel volt-ampere characteristics originating from the different open circuit voltages (Figure 5a). With this system of control there is only one possible setting of the generator for a given arc current and voltage.
2. Series field control has no effect on the open circuit voltage of the generator but changes the compounding of the generator and thereby changes the slope of the volt-ampere characteristic. With a combination shunt and series field controlled machine a group of volt-ampere characteristics having different slopes can be obtained for each open circuit voltage (Figure 5b). This type of control makes it possible to obtain a given arc current and voltage with several different machine settings.
3. Brush shifting control produces a series of variable slope volt-ampere characteristics originating from approximately the same open circuit voltage.
4. Leakage flux control on cross-field generators produces a series of slightly varying slope volt-ampere characteristics as shown in Figure 5c. By the use of a second control which inserts resistance in the short circuited brush circuit of this type of generator, it is also possible to change the slope of the volt-ampere characteristic. This combination of controls makes it possible to obtain a given arc current and voltage output with several different machine settings (Figure 5d).

The need for dual control welding generators which make possible variable slope volt-ampere characteristics is still a matter of conjecture because no definite relation has been found between the slope of the characteristic and the weld quality.

The electrical efficiency of a single operator welding machine will depend upon the generator design and the type of prime mover. Also, under normal conditions a welding operator actually welds only 30-60 per cent of

Figure 4 — Dynamic characteristics of arc welding machines.



the time. As a result, the no-load losses of the welding machine become an important factor.

The electrical efficiency of an induction motor-driven d-c generator will be about 50 to 60 per cent at rated load; the power factor of the induction motor will range from 85 to 90 per cent lagging. The efficiency of a d-c motor drive will be slightly lower than the a-c motor drive.

The no-load losses of the welding sets will depend largely upon the size and design of the generators. Compound wound generators have no-load losses ranging from 2 to 5 kw as compared to 2.2 to 2.8 kw for cross-field type generators. The lower losses in the cross-field type generators are obtained by the elimination of small windings in the shunt field, resistors, reactors, etc.

The elimination of parts containing small diameter wires, such as shunt fields, resistors and reactors, also has the effect of reducing the amount of current reduction obtained as the welding set heats up.

Typical results obtained from a cross-field and compound wound generator are given in Table III.

TABLE III

Per Cent Variation in Welding Current as Set Warms Up After Starting Cold

Set	1 hr	1½ hr	2 hr	2½ hr	3 hr
Cross-field generator	3.5%	4%	4.5%	5%	5%
Compound wound generator	17%	21%	23%	24.5%	25%

Low reduction in current resulting from the generator warming up from a cold start is important because it insures a more uniform current supply and reduces the time lost in resetting the machine in order to obtain the desired welding current.

The generator efficiency of a gasoline or diesel-driven welding set is the same as it is for an electrically-driven set. The gasoline or oil consumption of these types of equipment are an important factor, however. Actual operating data indicate that 300 ampere sets will use from 13 to 16 gallons of gasoline per day, depending on the efficiency of the unit and the ratio of welding to idle time. Cost data on diesel-driven sets indicate that this type of equipment can be operated at an oil cost of $1.00 per 8-hr day. It is important to mention, however, that the initial cost of a diesel-driven set will run from 50 to 60 per cent greater than the cost of a gasoline-driven set.

Multiple-operator machines — The multiple-operator machine is designed to supply current to more than one operator at a time. The generator is essentially flat compounded, consequently it is known as a constant potential machine. The welding current supplied to each operator is controlled by means of a resistance bank connected in series with the arc. (In some cases a reactance is also used in order to retard current changes.) By increasing or decreasing the resistance in the arc circuit the current can be decreased or increased to any desired value. The short circuit current is limited by

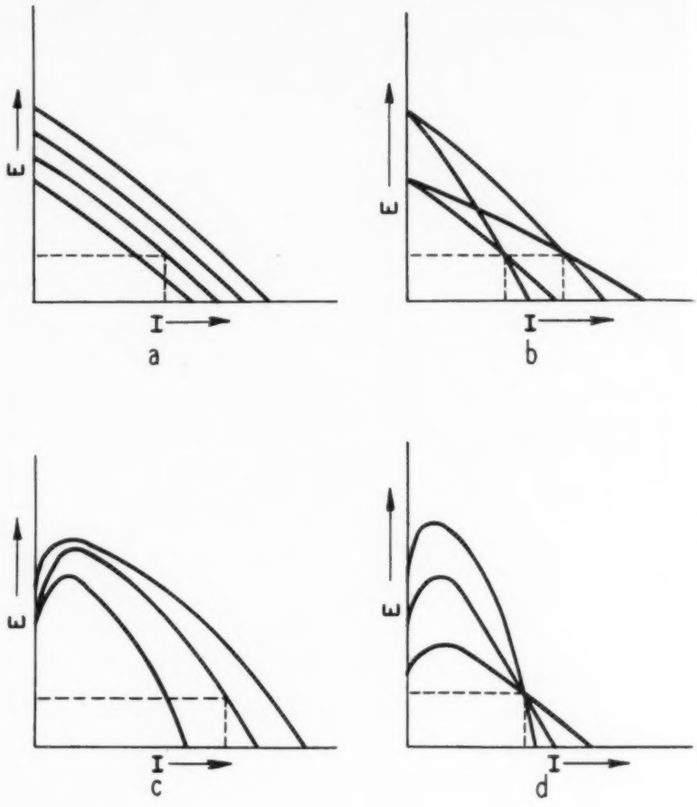


Figure 5 — Influence of generator control on static volt-ampere curves.

the amount of resistance in the resistance bank, consequently the volt-ampere curve of each welding station has the desired drooping characteristics. Figure 6 is a schematic diagram of a multiple-operator welding installation.

The current adjustment for the individual welding stations is accomplished by a series of knife switches which insert resistance into the circuit when they are closed. Each switch is calibrated and the desired welding current is obtained by closing the proper combination of switches.

Under normal welding conditions a welding operator holds an arc only a small percentage of the time. The rest of the time is consumed in changing electrodes, moving from one position to another, cleaning the weld, etc. When single-operator sets are used this means that the sets are running idle a large percentage of the time. With a multiple-operator set it is possible to have the total connected ampere load greatly exceed the generator rating and still not overload the generator because all welders are not welding at the same time. Figures from actual large size installations where the operators are welding at approximately 150 amp indicate that the average current drawn per welding station is about 50 amp.

Using an average current of 50 amp per operator, it

is seen that a 10,000 amp multiple-operator installation would handle 200 welding operators welding at 150 amp. Single-operator sets for these 200 welding operators would probably consist of two hundred 200 amp machines or a total of 40,000 amp capacity.

The efficiency of a multiple operator set might seem low at first thought because of the power loss in the current control resistance banks. Under proper conditions of application, however, this is not the case, as can be seen from the following analysis.

The electrical efficiency of a constant potential motor-generator set may be assumed as 80 per cent. With an open circuit voltage of 60 volts and an arc voltage of 24 volts it is seen that only 40 per cent of the power is used and that 60 per cent is lost in the current control resistors. The overall efficiency, therefore, is (.80) (.40) (100) = 32 per cent.

For comparison assume a 300 amp single-operator set operating at 200 amp at 24 v. It is also satisfactory to assume that the welding operator is actually welding ⅓ of the time. The efficiency of the welding set at ⅔ load is 53 per cent. The no-load losses of the machine when running idle are 2.5 kw.

The power consumed during welding is (200) (24)/.53 = 9.05 kw. The no-load losses are (2) (2.5) = 5 kw. The overall efficiency, therefore, is $\frac{(200)\ (24)}{14.05} = 32$ per cent, or the same as the efficiency of the single-operator set.

Even though the efficiency should be slightly better with the single-operator set, this difference is often compensated for by the difference in cost between the two types of equipment, the possibility of obtaining power factor correction by using a synchronous motor and the difference in floor space required for the equipment. The multiple operator set, of course, is not portable and in case of a forced shut-down would force all the operators on the line out of work.

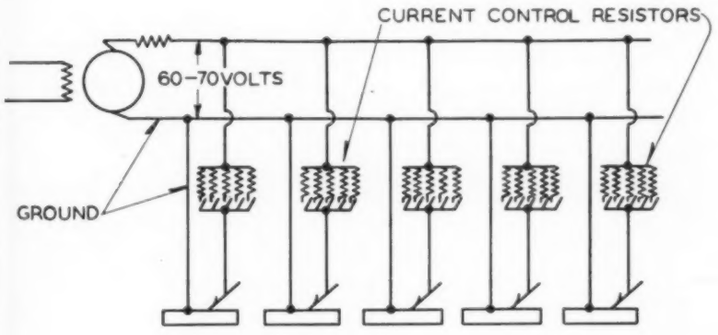


Figure 6 — Schematic layout of a multiple-operator installation.

In general it can be stated that the multiple-operator set is particularly advantageous in applications where the ratio of welding to overall time is low and where the welding currents used per operator are not large. Where the ratio of welding time to the overall time is high and high welding currents are used the single-operator set is generally preferred.

The increased use of multiple-operator sets within recent years is evidence that this type of equipment is considered by welding engineers to be desirable in many cases. The ampere capacity of multiple-operator installations since 1938, according to N.E.M.A. reports, is given in Table IV.

TABLE IV

Ampere Capacity of Multiple-Operator Installations

Year	*Total amperes*
1938	43,500
1939	90,500
1940	187,950
1941 (Jan. and Feb.)	153,800

Alternating-Current Machines

Alternating-current welding machines are being more widely used but as yet they have not obtained the popularity their qualities merit. The actual number of a-c machines purchased has gradually increased during the last three years but the ratio of a-c to d-c sets has remained about constant. According to N.E.M.A. reports, a-c machines constituted 12.4 per cent of the welding machines sold in 1939 and 1940. This percentage dropped to 10.5 per cent for the first two months of 1941.

A-c machines are of two general types — transformers and motor-generator sets. The transformer type is most commonly used and it combines simplicity and low maintenance costs. The motor-generator type a-c welding machines develop power at frequencies of 180 or 240 cycles. The high frequency is claimed to produce better arc stability and this point will be discussed in detail later.

Current control on transformer type welders is generally obtained in two ways. The higher capacity units use reactance control and this is usually obtained by means of a moving core reactor. Figure 7 shows diagrammatically the construction of such a machine. The primary and secondary windings are assembled on one leg of the core. The reactor winding is separate from the main transformer windings and is mounted on the same core structure. A movable core fits inside the reactor coil and completes the magnetic circuit of the core structure through a variable air gap. Raising or lowering the core to change the air gap controls the current output of the machine.

Low capacity units often have a combination control consisting of several voltage taps on the secondary winding and an adjustable series reactance.

The plain adjustable series reactance control produces a series of variable slope volt-ampere characteristics originating from the same open circuit voltage, usually 80 volts. The combination secondary tap and series reactance control produces several series of variable slope volt-ampere characteristics, each series originating from different open circuit voltages. With the combination control it is possible to obtain approximately the

same arc current and voltage output with more than one setting of the machine.

The electrical efficiency of a transformer welder operating at a 40 v load will range from 86 to 89 per cent. The power factor at 40 v load will range from about 56 to 58 per cent if capacitor correction is not used. The use of capacitors for power factor correction will greatly improve the power factor and reduce the kva input for a given kw output.

The advantages of increasing the power factor of individual welders by adding capacitors can be realized to the fullest extent only when the amount of corrective kva added to the individual unit is based on the average operating conditions. The kva drawn from the line by the welder itself varies approximately with the load. Most welders are designed to operate over a welding current range from 20 per cent of the normal rated load as a minimum to 125 per cent of normal rated load as a maximum. The amount of added corrective capacitor kva is, of course, constant. The power factor of the combination will, therefore, vary with the load. When welders are operating in groups, a diversity factor also affects the total resultant power factor of the group. Too much correction on the individual machines may be as bad as none at all.

The amount of correction applied to welders should be based on average operating conditions of individual units as well as diversity factors usually found in a number of welders operating together.

A lagging power factor of 80 per cent is considered to be a good point of economical power factor correction. Too high a power factor at full rated load may

TABLE V

Tensile Properties of D-C and A-C Welds

Electrodes		Welding position	Type of machine	Physical properties			
Grade	Size			Yield point lb per sq in.	Tensile strength lb per sq in.	Elongation per cent in 2 in.	Reduction of area, per cent
E-6020	1/4	Flat	d-c 60 v C.P.*	45,500	58,300	35.5	65.4
				49,700	59,000	35.0	64.5
Average				47,600	58,700	35.2	65.0
E-6020	1/4	Flat	d-c S.O.**	54,500	63,300	33.5	62.0
				50,500	62,000	32.0	55.0
Average				52,500	62,700	32.8	59.0
E-6020	1/4	Flat	a-c Trans.†	52,000	61,900	31.0	51.3
				49,500	60,000	32.5	52.5
Average				50,800	61,000	31.8	51.9
E-6012	3/16	Vertical	d-c 60 v C.P.	57,700	72,000	27.0	46.0
				58,700	72,100	23.5	49.8
Average				58,200	72,000	25.3	48.9
E-6012	3/16	Vertical	d-c S.O.	58,500	70,700	25.0	47.5
				58,600	71,500	29.0	58.5
Average				58,600	71,100	27.0	52.0
E-6012	3/16	Vertical	a-c Trans.	59,500	72,700	28.0	60.8
				59,200	72,400	27.5	49.0
Average				59,300	72,600	27.5	54.4
E-6012	3/16	Overhead	d-c 60 v C.P.	61,500	74,400	14.0	25.0
				62,100	75,500	19.5	27.0
Average				61,800	75,000	17.0	26.0
E-6012	3/16	Overhead	d-c S.O.	62,700	76,400	15.5	27.0
				61,700	76,200	18.0	27.0
Average				62,200	76,300	16.8	27.0
E-6012	3/16	Overhead	a-c Trans.	60,200	72,200	20.0	37.8
				61,500	74,500	18.0	35.0
Average				60,700	73,300	19.0	36.4

*Constant potential **Single operator †Transformer

result in a leading power factor at lower current settings, and too much correction can become as objectionable as insufficient correction. Figure 8 compares the difference in power factor and kva input for transformer type welders with and without power factor correction.

The no-load losses of a transformer unit are low and range from 150 to 375 watts on well designed machines, depending upon the size of the welder.

The method of current control used on high frequency motor-generator set type a-c welders is an adjustable series reactor which produces a series of varying slope volt-ampere curves originating from the same open circuit voltage. It is impossible with this type of control to obtain a given current and voltage output with more than one setting on the machine.

The motor efficiencies of a high frequency motor-generator set compare with those used on d-c welding equipment. Overall efficiencies vary with the size of the unit and the load and will approach about 65 per cent under 40 volt full load. The power factor of an induction motor drive approaches 65 per cent at 40 volts full load. No-load losses will depend upon the size of the unit and will approach 3.0 kw for large capacity machines.

Comparing the transformer and motor-generator set types of a-c welding machines it is seen that:

1. The transformer type has higher efficiency.
2. The transformer type has lower no-load losses.
3. With proper power factor correction, the transformer type will have better power factor.
4. The transformer type has no high speed moving parts to require maintenance.
5. The motor-generator set type can be driven from a d-c source or 3 phase a-c.
6. The motor-generator set type produces higher frequencies (180-240 as compared to 50 or 60 cycles with transformers).

The effect of high frequency on weldability is worthy of further analysis.

It has been stated that high frequency current for welding is advantageous because it eliminates or greatly reduces the dead periods of current flow which are supposedly inherent in 60 cycle current. These so-called dead periods or "coasting periods" exist during the time when the voltage of the alternating current is too low to maintain an arc; i.e., while it is decreasing and passing through zero and increasing with the opposite polarity to a potential sufficient to re-ignite the arc. These periods, of course, occur at each reversal of current, or every half cycle. The rate at which the voltage changes, for a given wave shape, is proportional to the frequency. Consequently, on the basis of this theory, the length of the "coasting period" for 180 cycle current is reduced to one-third and for 240 cycles to one-fourth the "coasting period" for 60 cycle current.

The conditions which actually exist in modern a-c welding sources, however, are very different. It may be assumed that there is always an a-c voltage equal to the open circuit voltage induced in the secondary of the transformer or in the armature windings of the a-c generator. In order to limit the current and to reduce the terminal voltage to a value suitable for the arc, a series inductive reactance is used internally in the welding circuit. A-c welding current flowing in the reactance produces a counter-voltage which subtracts from the induced voltage to leave the necessary low terminal arc voltage. Because of the inductive circuit, the welding current lags the induced voltage which means that the welding current passes through zero each time it reverses after the induced voltage has passed through zero and increased, with the opposite polarity, to near maximum value. As the current comes to zero, in the process of reversing, the arc does tend to deionize, which would mean it could not carry current. The moment the current stops flowing, or more specifically ceases to change, the counter emf in the reactance ceases to exist and full value of the induced voltage which is near peak value and of the opposite polarity

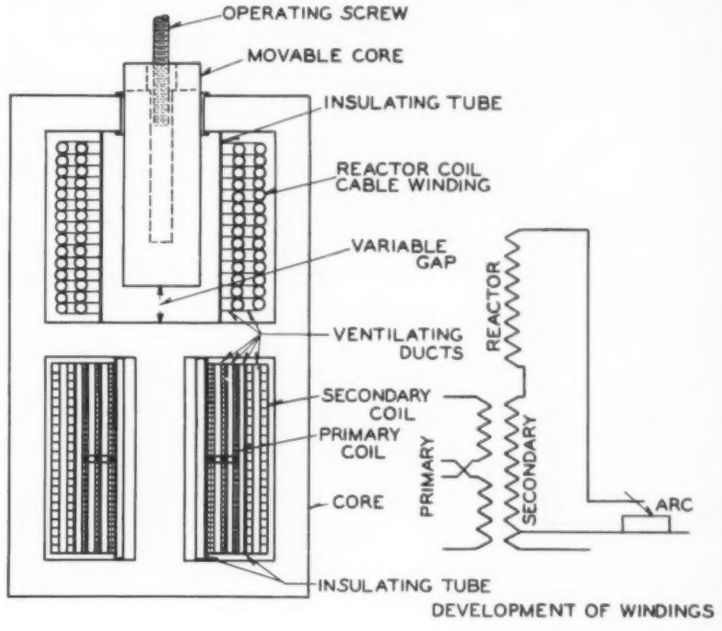


Figure 7 — Diagrammatic construction of an a-c welding transformer.

at the instant the current passes through zero is available and is considerably greater than necessary to immediately re-establish the arc and the current flow for the next half-cycle.

An oscillogram of arc voltage (upper trace) and arc current (lower trace) taken on a 60 cycle welding transformer is shown in Figure 9. It will be noticed that the voltage trace, as it reverses for each half-cycle, passes nearly perpendicularly through the zero line to a peak value before dropping back to a lower value for the rest of the half-cycle. The peak value of the voltage is the value necessary to re-establish the arc after reversal of current. The fact that the trace is perpendicular, or nearly so, shows that the action is instantaneous and that there is no deionization or coasting period.

Further oscillographic evidence that there is no "coasting period" may be seen from the current trace. A coasting period would mean the arc path is deionized,

its resistance to the flow of current is high and current would cease to flow or at least deviate from normal values. This condition would be indicated on the oscillogram by the trace coming to the zero line and following it for a distance representing a short period of time before increasing in the opposite direction. In the case of only partial deionization, the trace would deviate from its normal course and cause an offset in the curve near the zero line. Examination of the oscillogram indicates that the trace passes through zero in a smooth curve with no offset, proving that there is no appreciable period of deionization.

It should be remembered that arc voltage is dependent on and in phase with arc current. Arc current is entirely different in phase and magnitude from the induced voltage. The argument in favor of high frequency welding current is based on the erroneous assumption that induced voltage and arc voltage are in phase.

The previous discussions on a-c welding machines have been directed to single-operator sets. It is important to point out, however, that multiple-operator transformer welders are also available.

Multiple-operator transformer welding sets may consist of a main single-phase or three-phase transformer to which a number of adjustable reactors are attached. Each reactor represents a welding station and allows a welding operator to work independently of the others. Sets have been built with as many as 24 welding stations to one transformer.

Comparison of D-C and A-C Welding Machines

The previous sections of this article contain brief discussions on weldability and the characteristics of d-c and a-c welding machines. It is also desirable to make a direct comparison between d-c and a-c welding machines to aid in determining which type is best adapted for a given application. It is impossible to make any hard and fast rules regarding the selection of machines but if the individual conditions are known, the selection between d-c and a-c becomes an easy matter.

Choice of electrodes — One of the disadvantages of a-c welding machines is the limitation in the choice of electrodes. In order to strike and hold a steady arc with a-c it is necessary to have the arc path ionized by some source other than that normally accompanying a carbon or bare type electrode. This ionization is usually obtained by coating the electrodes with suitable ingredients. As a result, unless high voltage, high frequency stabilization is used, a flux coated electrode must be used with a-c machines.

The use of coated electrodes is not necessarily a disadvantage because nearly all welding is done with this type of electrode. The problem lies in the fact that all coated electrodes do not contain suitable ingredients to make them adaptable for use with a-c.

There is at the present time a wide variety of electrodes available that have been designed for use with a-c and it is possible with few exceptions to find a suitable electrode to weld any type of ferrous material, including austenitic stainless steel and high managnese steel and cast iron. Many hard-facing electrodes are also suitable for use on a-c.

The principal types of electrodes that cannot be used on a-c machines are carbon, aluminum, copper alloy, nickel, monel metal and inconel.

D-c welding machines are not subject to this limitation of electrodes. With this type of machine both bare and coated type electrodes can be used and electrodes are available for all types of material that can be arc welded.

It is important to point out that an electrode suitable for a-c welding is also suitable for d-c welding, consequently it is not necessary to carry duplicate stocks of electrodes where both types of machines are used.

Weldable materials — The materials that can be welded by using a-c machines are primarily determined by the electrodes that are available. If a suitable a-c electrode is available for any given material, that material can be satisfactorily welded with a-c. The principal materials that cannot be welded with a-c are aluminum, copper and copper alloys, nickel, monel metal and inconel.

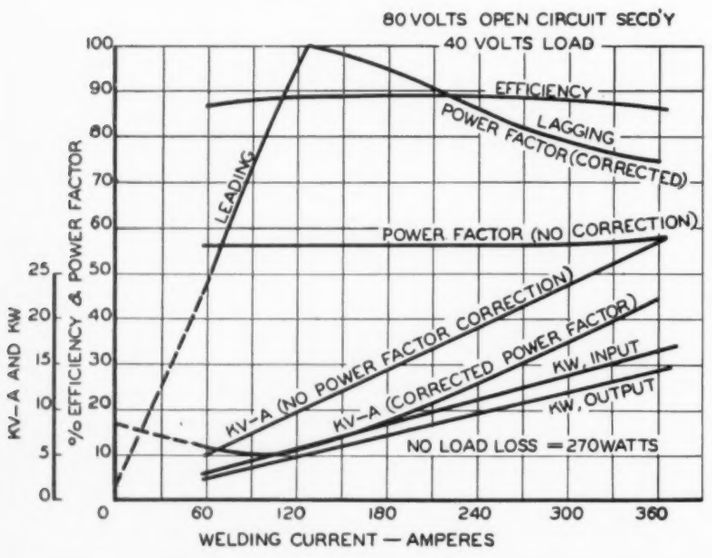
D-c electrodes are available for use on the nonferrous metals, consequently they can be welded with d-c machines.

Weld quality — There have been many arguments regarding whether or not a-c welds are as good in quality as d-c welds. If a good a-c electrode is used in combination with an a-c machine, the weld quality, from the standpoint of soundness, tensile strength, ductility, etc., will be equal to that of a weld made with a good d-c electrode on a d-c machine.

Table V gives data from comparative tests made on a-c and d-c machines, using electrodes designed for use on a-c and straight-polarity d-c.

Examination of Table V indicates some variation in the results obtained from the different types of welding machines. The greatest scatter was found in the ductility measurements, as might be expected, because the pres-

Figure 8 — Performance of 300 amp a-c transformer welder with and without power factor correction.



ence of a small gas hole will greatly influence the ability of a test specimen to neck down before fracturing.

In nearly every case the variations are small and within the normal scatter of weld tests. It is obvious that there is no definite trend indicating that one type of welding equipment gives better results than the others.

X-ray examination of welded joints indicates that satisfactory welds can be made with all types of machines. In the vertical and overhead positions a-c welds often appear to have slightly better soundness. This condition is believed to be the result of the reduced arc blow obtained with a-c.

Welding speed and efficiency — One of the primary factors in welding is cost. Neglecting overhead and maintenance, the difference between the costs of welds made with d-c and a-c welding machines would be influenced by deposit efficiency, deposit rate, ease of striking the arc and general welding characteristics.

Data on deposit efficiency and deposit rates, obtained from tests made with three grades of electrodes on three types of machines, are given in Table VI. All tests are based on welds containing approximately 2 lb of deposited metal.

Analysis of Table VI indicates very little variation in the results obtained from different power sources. In nearly every case the variations obtained are within the experimental error of this type of test. On the basis of these data, therefore, it may be assumed that the power source (a-c or d-c) has little or no influence on the deposit rate and deposit efficiency of properly designed electrodes.

In production work where an operator is melting 200 or more electrodes a day, the ease of striking the arc is of considerable importance. The actual time of striking might not be important, but if several attempts are required before the arc is established, there is danger of obtaining undesirable weld quality at the location of striking.

The time required to strike an arc can be used as a measure of striking ease, consequently the following tests were made on d-c and a-c machines.

The welding operator was instructed to run short beads of weld metal on a flat plate of hot rolled steel. A stop watch was used to measure the lapsed time from the instant his electrode holder moved to strike the arc until the arc was broken. A relay-operated clock was used to obtain the time the arc existed with a suitable welding voltage. The relay control circuit was designed so that voltage conditions at short circuit and open circuit did not operate the clock. The differences in the two measured times is the arc striking time.

Table VII contains average arc striking times and

TABLE VI

Electrode Deposit Efficiency and Deposit Rate

Electrode		Welding position	Welding data		Type of machine	Deposit efficiency per cent	Deposit rate oz per hr
Grade	Size		Current	Voltage			
E-6020	1/4	Flat	298	35	d-c 60 v C.P.*	70.5	118.00
E-6020	1/4	Flat	300	35	d-c S.O.**	69.6	118.0
E-6020	1/4	Flat	300	35	a-c 60† Trans.	70.4	117.0
E-6012	3/16	Vertical	190	23.5	d-c 60 v C.P.	81.0	64.0
E-6012	3/16	Vertical	185	23	d-c S.O.	81.4	65.1
E-6012	3/16	Vertical	185	23	a-c 60 Trans.	81.5	63.2
E-6012	3/16	Overhead	187	25	d-c 60 v C.P.	77.5	54.6
E-6012	3/16	Overhead	190	22	d-c S.O.	75.3	54.0
E-6012	3/16	Overhead	190	23	a-c 60 Trans.	79.7	54.0
E-6013	5/32	Vertical	160	....	d-c S.O.	79.5	50.4
E-6013	5/32	Vertical	160	....	a-c 60 Trans.	78.0	50.0
E-6013	5/32	Overhead	160	....	d-c S.O.	72.0	44.6
E-6013	5/32	Overhead	160	....	a-c 60 Trans.	76.0	45.9

*Constant potential **Single operator †Transformer

includes two current values on two sizes of each of the three grades of electrodes listed. Each tabulation represents the average of 80 starts, 40 starts being made with new electrodes and 40 starts being made with electrodes that had previously been used.

TABLE VII

Average Arc Striking Time in Seconds

Electrode	Position	D-C constant potential set	D-C single operator set	A-C 60 cycle transformer
E-6012	Flat	.16	.35	.27
E-6020	Flat	.81	.83	.66
E-6013	Overhead	.61	.61	.64
General average.....		.53	.60	.52

Examination of Table VII indicates considerable variation in arc striking time in certain cases but on the overall average a-c machines are equal to d-c machines.

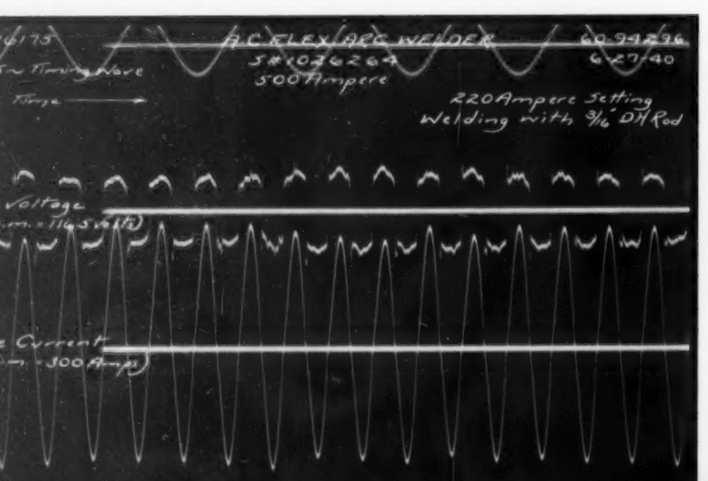
The general welding characteristics of a-c machines, assuming the proper electrodes are used, are equal or superior to d-c machines. The greatly reduced amount of arc blow obtained over d-c power is of prime importance in many cases. The relative lack of arc blow makes a-c machines particularly adaptable on structures containing many angles and curves, and in cases where large diameter electrodes and heavy welding currents are used. Arc blow makes it difficult for an operator to make a good weld, consequently it tends to slow down the welding speed. The reduction of this phenomenon by using a-c machines should have a tendency to increase overall welding speeds.

Penetration — It is sometimes stated that it is not possible to obtain as much penetration with a-c as with d-c. This statement is probably drawn from the fact that the energy at the anode of an arc is greater than the energy at the cathode. With d-c welding the choice of polarity will affect the energy distribution between the electrode and the work. With a-c welding the polarity reverses every cycle, consequently the energy is the same at the electrode and at the work.

Examination of a great many groove and fillet welds made with both a-c and d-c machines has indicated that it is possible to obtain satisfactory penetration with both types of equipment.

Maintenance costs — The relative difference in maintenance costs of a-c and d-c equipment is a varying item. The a-c transformer type welding machine has no rotating parts to wear or be greased and it has no brushes, consequently it is to be expected that this type of equipment would have a lower maintenance cost.

Figure 9 — Welding oscillogram taken on a-c machine.



Conclusions

It is apparent that satisfactory welding can be produced with all of the different types of welding equipment — a-c, d-c, single-operator and multiple-operator sets.

The choice between single-operator and multiple-operator sets is dependent upon cost considerations, possible power factor conditions and work requirements. The multiple-operator set is particularly advantageous in cases where the ratio of welding time to overall time is low and the current required per operator is low (use of electrodes less than ¼ in. in diameter).

Weldability of the different types of machines is a controversial subject upon which machine designers and welding operators do not agree in all cases. It is important to point out, however, that the static volt-ampere curve of a welding machine cannot be used as the only guide of weldability. In metallic arc welding the dynamic characteristics of the machine must be taken into consideration.

The efficiency and maintenance costs of welding machines are closely associated with their design and construction. Low no-load losses are an important factor when the ratio of welding time to overall time is low. The percentage current drop obtained as the welding machine heats up from a cold start is also important, particularly if the machine is used near its full load rating or if the machine is located some distance from the operator.

A-c machines of the transformer type have a higher electrical efficiency than rotating machines but they have poorer power factor unless power factor correction is used. An a-c transformer welder with proper power factor correction is the most efficient type of single-operator welding set.

A-c welding machines are somewhat restricted in their application because suitable electrodes are not available for the welding of non-ferrous metals such as aluminum, nickel and copper alloys. Suitable a-c electrodes are available for nearly every welding application on ferrous materials and in such cases the welding efficiencies, costs and quality are equal to or slightly superior to those obtained with d-c welding machines.

The major advantage of a-c over d-c welding is the greatly reduced amount of arc blow obtained. This condition is particularly advantageous on structures containing angles and corners and when large electrodes and heavy currents are used. The uniform distribution of energy obtained with a-c between the electrode and work is of particular advantage when welding thin material. The use of reverse polarity d-c often causes excessive heating of the work, which results in excessive distortion or the burning of holes through the work. The use of straight polarity often results in excessive heating of the electrode when enough current is used to obtain proper fusion of the work.

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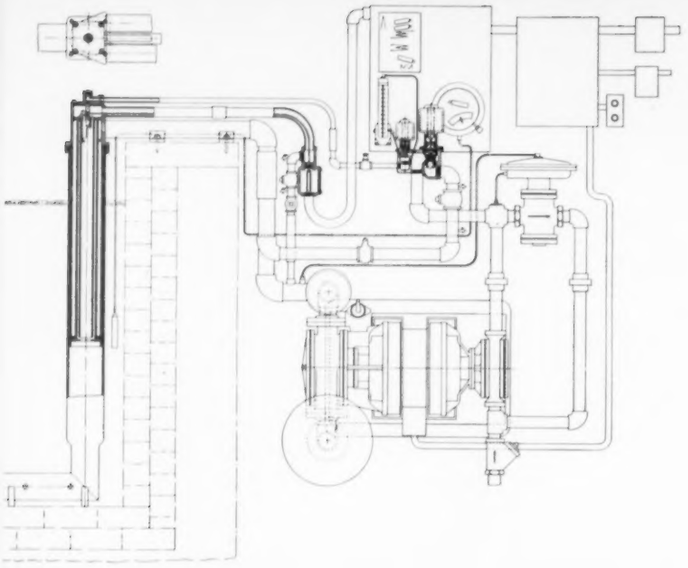


By W. G. See

Submerged Combustion Co. of America, Inc.

Hammond, Indiana

Presented before A. I. S. E. ANNUAL CONVENTION
Cleveland, Ohio

Figure 1 — Sketch showing general arrangement of complete assembly for submerged combustion heating in pickling tank.

SUBMERGED COMBUSTION HEATING *for Pickling Baths*

▲ ALTHOUGH there is much current discussion about submerged combustion this is due more to the recent developments than to its newness. As a rule operating men are extremely conservative in their acceptance of any new method or that which differs radically from old and accepted systems. As a result, there is much to be done in educating operating men to the many advantages to be obtained through the use of this method of heat generation and agitation.

Actually submerged combustion is a development which extends back to 1887 when Brunler developed the first submerged combustion burner. This burner was ignited by hand and then lowered into the vat to be heated. When the vat reached the desired temperature, the burner was turned off by hand. When the solution cooled and more heat was needed in the vat, the burner was removed from the liquid, ignited and again submerged. The material used in this burner was not corrosion resistant and therefore it was not feasible for use in acid solutions.

Eleven years ago the desire for a submerged burner which would be practical for use in pickling and which could be automatically ignited and controlled prompted a man well versed in steel mill practice to begin experiments with a burner of this type. In order to duplicate the corrosive atmosphere and rough treatment to which pickle room equipment is subjected, all test work was done in a pickle room under actual working conditions. The results obtained from the use of the first experimental burner were amazing. From this point on it was purely a matter of simplification and improvement. When placed on the market four years ago the burner had a simple and reliable ignition and control system. The metal used in the burner could be guaranteed for one year with an expected service life of two years or more. Even then the entire burner did not need to be replaced for the design permitted sectional replacement of that portion which was attacked most quickly. This meant rapid and economical repair with no loss of production time.

Simply stated, this submerged combustion system consists of a control assembly designed so that the operator or watchman has only to press a starting button to put the entire unit in operation. Figure 1 is a cross section of the burner. Here you can see the ignition point, pilot flame and the main flame along with the controls. When the unit is shut down, the solution in the tank being heated seeks its own level, completely filling the combustion chamber and part of the burner manifold.

When the starting button is pushed, an especially designed gas-and-air compressor is started up. The compressor delivers the products of combustion at a pressure sufficient to overcome the head of liquid in the tank. As the compressed air is purging the burner of solution the control system begins to operate. Automatically a hot wire igniter is heated to incandescence by the passage of a high amperage low voltage current, and after a predetermined time a flow of pilot gas is admitted to the burner where it is ignited. The main gas flow is then permitted to flow into the burner where it is ignited by the pilot flame. The air-gas ratio is automatically controlled to give maximum combustion efficiency. The burner might be classed as a nozzle mixing type with no possibility of back firing.

The burner plate is located beneath the solution level to insure the cooling of the combustion chamber by the surrounding liquid. The tubular combustion

chamber conducts the heat and products of combustion down to and across the bottom of the tub where they are vented and distributed to give the rate of agitation desired.

Following the ignition of the main gas flame the burner controls lock themselves into a running position until the desired solution temperature is reached. The thermostat then acts to shut off the gas flow and thus stop the heat in-put. However, the control mechanism is so designed that the air continues to flow through the system to maintain a fixed rate of agitation regardless of solution temperature.

When the thermostat registers a demand for heat, the controls recycle to automatically establish and ignite the gas flows. With the heat in-put so controlled, the solution temperatures can be maintained as close as one-half of one degree if necessary, but for the average department, the control range is usually set at from 3 to 5 F.

The combustion efficiency of these burners is high. The burners can be set to give any flue gas analysis desired. Orsat tests are run by inserting the end of a ¼ in. pipe into one of the exhaust holes in the combustion chamber and thus conducting the products of combustion to the orsat. The general practice is to set the burners for about five per cent excess air.

Burners are supplied in either single or double units. A single unit consists of a compressor, burner, and the necessary apparatus for ignition and control. Rated capacity of the single units range from 250,000 to 1,250,000 Btu per hr.

In a double unit, two burners are connected to one compressor, the controls remaining essentially the same except that provision is made for additional ignition current and the gas and air controls are arranged so that these flows can be adjusted for each burner.

The company which installs the unit makes a guarantee of material and workmanship for a period of one year. This guarantee includes the metal when immersed in sulphuric or hydrochloric acid. During the early days of development, many metals and non-ferrous materials were tested for use in the burner. All of those tried at first had some disadvantage for use with submerged combustion and three years passed before the metal was developed to meet the rigid requirements set for it. In the cross sectional figure it will be noticed that the burner is protected from the agitated acid by a lead covering. In an earlier design the lead covering was not used, and the burner was subject to attack by 10 per cent sulphuric acid at 170 F while the burner was running.

Submerged combustion can be used to advantage in many applications of solution heating. It is especially adaptable to the rapid distillation and concentration of liquids. With a pH control it is an excellent water softener. It may be used to heat and agitate many types of cleaning solutions. However, one of the most practical applications for submerged combustion is pickling. As you all know, the rate of scale removal from steel is increased by agitation and aeration. Agitation may be accomplished either by moving the work while in the solution or by moving the solution about the work.

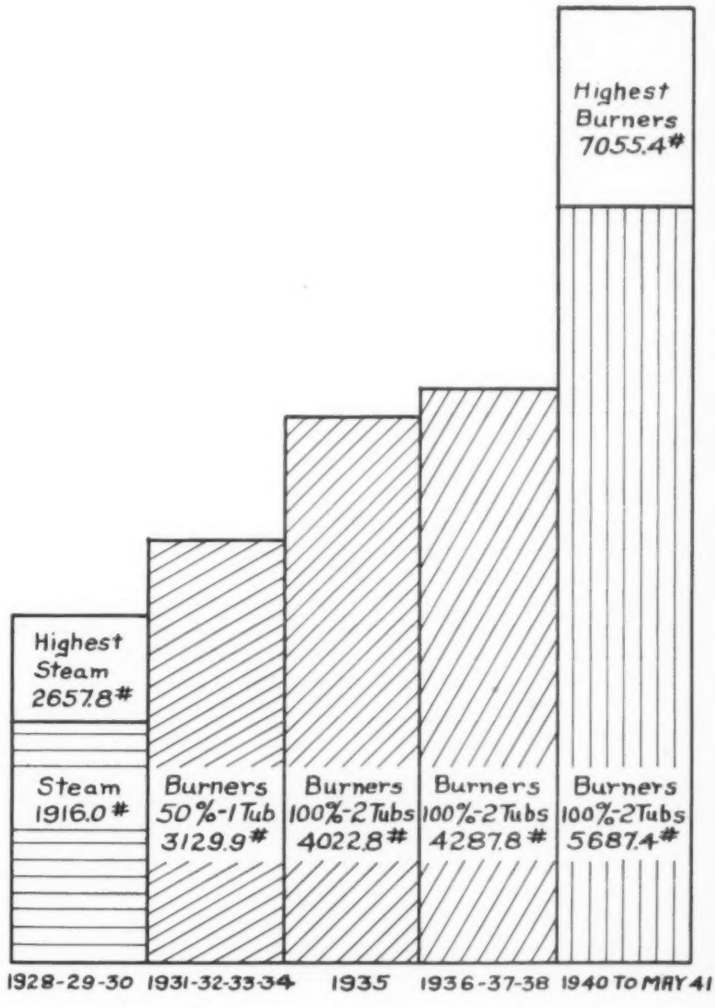
With submerged combustion, the products of combustion are exhausted directly into the solution. This creates a terrific agitation and the pickling solution, generally dilute sulphuric acid, is agitated and moved about the vat at a rate which would be extremely difficult to achieve mechanically. As a result, the average pickling time on various grades of steel are reduced 40 to 70 per cent of former practice if the operating temperature is held the same as it was with steam. The agitation also serves to keep the temperature extremely uniform throughout practically any size tank.

In general the trend for pickling temperatures has been downward in recent years. The lower temperatures have much to offer where they can be used and still meet production demands. Pickling temperatures of 185 to 195 F are expensive from many standpoints. Surface heat loss at 190 F is almost twice that at 160 F. More heat is required to bring the steel up to temperature and there is more dilution from condensation. Besides these very concrete cost factors there is a much faster deterioration of handling equipment and building structure.

The only reason why many plants use temperatures of 185 to 195 F is because it is the only way they know to obtain the tonnage necessary to keep their machines supplied. However, the amount of tonnage obtained from a still tank heated with steam to 190 F can be equaled by submerged combustion at 160 F. The benefits in reduced heating costs and operating conditions from this lower temperature are obvious.

In an article "Essentials of Good Pickling Practice"

Figure 2 — Chart showing graphical comparison of pounds of wire pickled per man-hour with steam and with submerged combustion.



by P. R. Russell of the Republic Steel Corporation, the following illustration of excessive operating cost due to high temperature in the pickling vats is clearly brought out. In this particular case the pickling house for this wire mill was inadequate.

"To fill the 'bake oven' of this particular mill with sufficient number of rods to keep the rod blocks supplied with pickled, limed, and dried rods, a pickling cycle of 12 to 15 minutes had to be maintained. As there were only four two-pin pickle tubs, an excessive temperature of around 190 to 195 F and an acidity of 5 to 7 per cent was necessary. If two more pickle tubs had been added to this pickle house and the proper use of a good inhibitor incorporated in the practice, operating temperatures could have been reduced to 155 to 160 F and the pickling cycle increased to 20 to 25 minutes. The net result of this added capacity and the consequent change and improvement in practice would be a saving of approximately 10 lb of acid per ton of rods pickled.

"The question naturally arises, would the expenditure for added equipment be justified? A brief consideration of the following data will prove conclusively that such added equipment would prove economical.

"The production of pickled rods required in the mill under consideration runs about 6000 tons per month. Let us assume that the cost of acid is about $12.00 per ton. The net monthly saving effected by the additional equipment and the improved practice would be about $360.00 per month — a saving which would look good on the cost sheets of any mill.

"There are also more intangible savings. These are, mainly: added life of equipment, reduction of steam losses and practically the elimination of unnecessary metal loss. In addition to these, there will be a large saving made possible by more efficient labor due to improved operating conditions."

Now the conclusion arrived at by Mr. Russell was logical and correct from the standpoint of steam heat in the vats. Using submerged combustion, however, the conclusion would be quite different. It would then be as follows: Equip the present four acid tanks with submerged combustion burners. Drop the working temperature to the same level, namely 155 to 160 F and maintain the original time cycle of 15 min. Due to the effect of direct firing the acid saving would be the original ten pounds per ton plus approximately 40 per cent of acid added during the life of the solution. Added to the intangible savings would be no steam loss as none would be required.

Let us look at a case in a wire department where these units are now in operation pickling No. 5 gauge to 3/16 in. wire.

Pounds per man hour are given in place of total production figures because of the extreme fluctuations in business during the past ten years. In making a comparison of this sort, it must be remembered that an excellent figure in one plant may be considered poor in another depending on the set-up. For this reason the following pounds per man hour are good only as a comparison of "before and after" the use of submerged combustion.

In this particular plant there are two coil tanks, one holding two pins, and one holding five pins of coils. In 1928, '29 and '30, open steam jets were used to heat the solution. The average pounds per man hour during this three year period was 1916.0.

In 1931 the first burner was installed experimentally. During the next four-year period the burner was running on an average of 50 per cent. During this four year period with only the two-pin tank equipped with a submerged combustion burner and that burner operating only 50 per cent of the time, the pounds per man hour rose from 1916.0 to 3129.9. This shows a decided increase.

The following year, 1935, was the first year a submerged combustion burner operated on a scale which made it commercially feasible. In this year the burner was kept running every production day of the year. Again the pounds per man hour went up from 3129.9 to 4022.8. This showed an increase over the 1928, '29 and '30 period of 209.9 per cent and an increase of 128.5 per cent over the 1931 through 1934 period. In 1936 both wire tanks were equipped with burners. Again the pounds per man hour went up. This time, however, the rise was smaller due to the inability of the men and auxiliary equipment to handle the steel. The new pounds per man hour figure rose to 4287.2 for the period 1936 through 1938. In 1939 the pressure to get increased production began to be applied. In the period 1939 through May 1941 the pounds per man hour again rose to 5674.4. This showed an increase of 132.4 per cent over the 1936 through '38 figure and a total increase of 296.2 per cent over the original steam heated vat pickling figure.

The figures available for the three years before 1931 when steam alone was used show 1429.9 pounds per man hour to be the lowest attained in that period while the highest figure was 2657.8 pounds per man hour. Compare this with the highest figure of 1941 which was 7055.4 using submerged combustion. This is 5625.6 pounds or 265.4 per cent above the highest steam figure in that period.

For the sake of simple comparison let us level off these high and low figures and use an average figure for the above periods. The average pounds per man for 1928, '29 and '30 was 1916. During 1939, '40 and '41 through May of the last named period the pounds per man hour averaged 5674.4. This is an increase of 296.2 per cent and was obtained with no additional equipment other than submerged combustion burners in each vat.

Although the figures on bar pickling are not so complete as those given on wire, here are a few which may prove of interest. Prior to using submerged combustion, the bar vats in this plant were run at 190 F. The pounds per man hour averaged 5650. With the installation of submerged combustion the temperature was dropped to 160 F and yet the pounds per man hour figure rose to an average of 7926.6 pounds for the two years the burners have been in operation. This is an increase of 40.3 per cent in bar production after lowering the solution temperature from 190 to 160 F.

Along with this increase in production definite economies are effected. When live steam is used to heat the solution condensation results. This condensation and its subsequent dilution of the acid is costly, especially at the higher temperatures. In some plants it raises the working level of the solution to a point where it is

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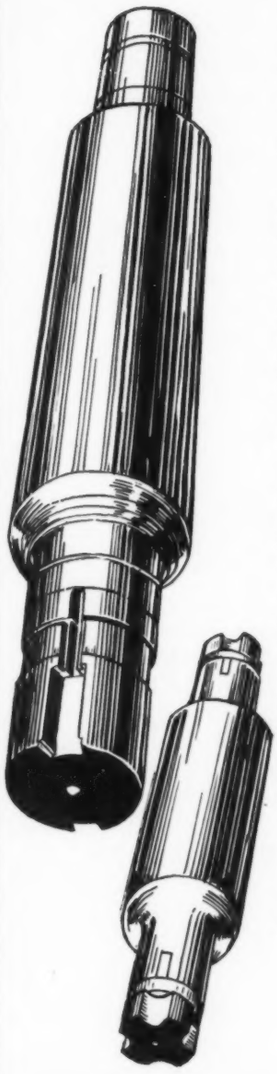

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H. H. Seaman

President and General Manager

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Rolls & Rolling Mill Equipment

AVONMORE, PA.

necessary to drain off a part of the bath to maintain the proper working level. A certain percentage of acid is lost in this manner and besides this, concentrated acid must be added to the remainder of the bath to bring it back to the required strength.

When submerged burners are used, however, dilution is eliminated. In fact the direct firing evaporates water and tends to concentrate the solution so that a small amount of water must be added to maintain the solution level at the desired point. Besides the acid thus saved by eliminating dilution, the terrific agitation causes a scrubbing action on the chemically loosened scale. This creates a further saving in acid which totaled may equal 25 to 50 per cent of the acid added during the life of the solution. Sometimes these figures are bettered as was the case in one cold finishing plant. Using almost idential production years for comparison, this plant showed one year's acid cost to be $22,418 when steam was used and only $10,145 for acid after installing submerged combustion.

This savings in actual acid consumption is beginning to have even greater benefits as more and more states pass stream pollution bills and set up sanitary districts. In most cases this means the spent acid must be hauled away to a pit, or the iron must be settled out and the acid neutralized or machinery must be obtained to either reclaim the acid or to process it in some way. In any case, the lower acid consumption effected by submerged combustion means less used acid to be hauled away or otherwise processed. Further, due to the evaporate effect of these burners solutions level can be allowed to drop before tub dumping time so that even less used acid solution will have to be handled.

It is only natural that tSe generation of heat right in the solution should result in decreased heating costs. As the heat needed for each vat is generated in that vat, this means complete independence of a central boiler house whose efficiency falls off at anything under full load rating. In many plants the boiler is run in the summer only for the pickle room. Submerged combustion burners in acid vats and immersion heaters inthe lime solution allows the boiler house to be shut down completely during warm weather for even greater savings in heating costs. In fact, one plant operating under these conditions found it advantageous to discontinue operating the boiler entirely and to heat the plant with a coal fired hot air system.

One user of submerged combustion has found it possible to pickle one tone of steel rods at a fuel cost of five cents per ton using 1000 Btu gas at 50 cents per thousand cubic feet. A plant — producing sheet — has showed a heating cost of 1.07 cents per net ton using gas which cost 20 cents per million Btu.

In concluding the production discussion of this paper let me summarize the advantages which can be effected by the use of submerged combustion burners. In many cases these advantages develop a total savings of about 50 per cent of present pickling costs. Production is increased, and labor costs are decreased proportionately. Acid is saved and the number of rejects due to improper cleaning are reduced and a more uniform product is obtained. Most users are able to retire the initial cost of these units in one year from the savings effected by their use.

DISCUSSION

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PAUL LEISS: The paper presented by Mr. See covers the subject in all its phases and there is little that I can add except to verify the facts and elaborate a little on some items. There is no doubt in my mind of its many advantages. In one plant which I visited and at which authentic figures are available, a year's comparison operating on steam as compared with a year's operation with submerged combustion, showed a steam cost of 45c per ton as compared with 13c with natural gas at 75c per 1000 cu ft. In the same periods, acid consumption dropped from 23.1 to 18.4 per ton, a reduction in cost of 4.7c per ton or about 20 per cent. In this particular case, the pickling bath temperature was brought down from 185 F (with steam heating) to 155 F with submerged combustion, along with an increased pickling speed of 20 per cent. The products pickled were bars and rods. This plant was a case where the boiler house was operated during the warmer months of the year only for pickling.

Other factors which Mr. See touched upon which I believe are worthy of considerable thought, are its bearing on spent acid disposal and building deterioration.

Another important decision is that with lower temperatures, there is less likelihood of certain troubles in pickling, such as over-pickling and blisters.

From an operator's viewpoint, there is the objection that with this type of heating, the pickle bath cannot be brought up to 210 F. With the present rush of business, this, to him, is a very serious matter, regardless of the fact that he can get as good or better rate of pickling than he can with steam. As long as he is not up to 210 F, he feels that he could get a still higher rate of production and feels that something is lacking and it is difficult to convince him otherwise.

Another worry from the operator's viewpoint, is on strip pickling where multiple strips are going through a tank, too violent agitation might tangle the light gauge, narrow sizes inside of the tank. This is a very real difficulty, particularly in the steel plant at which I am connected, where we pickle in widths from ¾ in. up to 37½ in. wide with multiples as high as 12 and as light as .035 in. thick.

MEMBER: I would like to ask what is the limiting temperature on a water-acid solution to be heated by submerged combustion, and where does the efficiency start to drop off as the temperature is raised?

E. B. RESSLER: Our continuous pickling tanks are rubber-lined tanks. We don't allow any open flames in the pickling department — no burning torches and not even smoking. We have been wondering, then, whether or not in the failure of these tubes there may be a possibility of igniting the rubber in the linings. I would like Mr. See to express himself along that line.

W. G. SEE: I think the first question was at what point of temperature does the efficiency begin to fall?

To answer your question, the efficiency on the burner is about 96 per cent at 140 degrees Fahrenheit. At 160 F the efficiency drops down to eighty-eight; at 175 F, to about eighty-four. The practical high temperature for operating submerged combustion equipment is 175 F. We usually standardize at 165 F. In our own test work the highest temperature we have ever obtained is 186 F. The theoretical maximum is 192 F.

Now, the question about the possibilities of explosion in a covered continuous pickling tank due to, shall we say, gas escaping in the burner and then being lighted. Is that the general idea of the question?

E. B. RESSLER: I repeat it, to give you my idea of it. There comes a time when your tubes will fail. They will probably fail during operation. Will there be a flame, then, impinging on the side of the tank which may ignite the rubber?

W. G. SEE: No sir, there will not be. In all underwater work or under-solution work, regardless of where the holes for the escaping combustion gases or air are placed, at the pressures we use, they will not possibly go more than two inches from the combustion chamber. From there it goes straight up. We have operated these burners in wooden tanks with the holes drilled within an inch and a half of the wood. We have operated them in tanks lined with brick laidup with a sulphur cement. Sulphur burns readily, and when it does burn you can smell it all over the place. However, we have never found any trace of burning the tank lining in any vats in which we are operating our equipment. This holds true even in cases where the combustion chamber has been broken or torn loose by a shifting load or supporting chains breaking and spilling the load.

In the case of a closed vat, such as a continuous tank, we can see no possibility of explosion or difficulties encountered from the use of submerged combustion heating.

Mr. Leiss and I have a standing argument on the high temperature used in strip pickling. I believe we have the answer for his desire for a temperature of 200 degrees F, although I, personally don't approve of this temperature. The reason I don't is because it is above the maximum for submerged combustion, and further, I don't believe it is necessary. However, we can attain it by a dual burner set-up. This would consist of an immersion burner which burns the flame in a tube and exhausts outside of the solution through that tube, along with a submerged burner to exhaust the products of combustion

directly into the solution to get the agitation desired for the maximum efficiency and speed in pickling. You are now pickling at 210 degrees F and I claim that submerged combustion can equal your production at 175.At 210 degrees you are just about at the end of the rope as far as production goes. At 175 degrees with submerged combustion you still have a potential reserve of 35 degrees. When pressed for production the temperature could be raised to 210 degrees or whatever temperature was necessary, by adding steam. When the emergency had passed, steam could be eliminated and normal production maintained at the far more economical temperature of 175 degrees.

Submerged combustion does not take the place of mechanical agitation. In other words, let's assume we have a still tank pickling at 175 degrees. Let us assume that you can pickle steel of a certain analysis in one hour. If you put in mechanical agitation of some type to shake or move the material being pickled, you will cut that time down to about half an hour. If you take out the mechanical agitation and put in submerged combustion, you will also cut the time down to a half hour. However, if you have the mechanical agitation in the vat and install submerged combustion in conjunction with it, you will cut your time down to about 15 minutes.

The fumes from submerged combustion that come off a pickling vat heated with submerged combustion contain less acid by actual tests than they do over a still vat heated by steam. This is probably due to the fact that the fumes contain more moisture and less actual acid.

There may be some questions which I didn't have a chance to get down as they were being asked. Have I answered them all?

O. LUTHERER: What regulates the upper limit of temperature you can obtain with a submerged burner?

W. G. SEE: The upper limit of your temperature is set by your agitation — by your evaporation. You are evaporating faster than you can heat and regardless of how many Btu you put into any given tank, you will not attain more than the 192 degrees theoretical maximum. For example, we used a million and a half Btu per hour to heat a 300 gallon tank for testing purposes. We attained a temperature of 186. We shut off the gas, but let the air continue to flow. Within sixty seconds our temperature had dropped back to approximately 172.

Does that answer that question?

O. LUTHERER: That brings out the fact that even though the combustion efficiency is high, the efficiency of the operation is low at high temperature.

W. G. SEE: Low, at high temperature, yes. The fuel efficiency at high temperature is low because of the loss from the whole of the vat. This is also true of any type of heating.

H. L. ANTHONY: Can you maintain a foam blanket on a pickle bath with a submerged combustion burner?

W. G. SEE: You can keep a foam blanket on top of the vat as a whole but not directly over the combustion chamber. Is that clear? There is too much agitation. It will spread and give you a spot over the combustion chamber of about two or three feet in width, depending on the way your combustion chamber is running in the vat. There is another thing on that subject. If you use a foaming material you require only about one third the normal amount. Otherwise, the agitation and aeration would have created such a heavy blanket that the foam would rise high enough to run over the sides of the vat.

L. A. KLINE: I have a few remarks to add to Mr. See's very interesting paper in connection with one particular installation with which I am familiar, that is, a still pickling vat steam-heated for the preparation of billets for a chipping bed. In this particular installation, the vat, in order that it might be served by the same crane that serves the chipping bed, is, of necessity, located close to the chipping bed.

As Mr. See pointed out, in a steam-heated vat the temperature is carried rather high. This limits the use of the foam-forming material to control the acid fumes. Consequently, acid fumes are present not only around the vat but also around the chipping bed and many complaints are heard from the chippers.

With the use of submerged combustion and lower operating temperatures, more foam-forming material might be used, and the fumes around the pickling bed controlled.

This particular installation was limited in capacity by the method of operation, which is as follows: At the start of the run, a batch of the acid was mixed and ten to twelve lifts of bars, possibly ten tons each, were run through the bath. By this time the acid had weakened to a point where a long time was required to pickle the last lift.

This cycle required about eight to ten hours, so that the capacity was about 200 tons a day. Investigation indicated that by the addition of acid, after every second lift, as many as 30 to 35 lifts could be run through the bath. This cycle required about 16 hours, increasing the capacity of the vat to about 400 tons per day.

However, the strength of theacid was not then the limiting factor, but the addition of acid and condensation of steam raised the level in the vat to a point where it was about to overflow. Since no overflow was provided, it was necessary to dump the vat and clean, with the attendent loss of good acid.

The use of submerged combustion would eliminate the rise in level due to steam condensation and would tend to evaporate some of the water from the bath. This may allow the pickling operation to be carried to a point where the acid strength and iron concentration would be the limiting factors.

This particular vat is controlled by an automatic temperature control. As each lift of steel is placed in the vat, the steam valve is opened wide and agitation is obtained for a time until pickling temperature is reached, then the steam flow is cut down or closed off entirely and agitation is lost, thereby extending the length of pickling time required.

The use of submerged combustion would maintain agitation throughout the entire cycle, thereby reducing the time required for pickling each lift of steel.

Mr. See has pointed out that in a plant where a boiler house is operated for heating pickling baths, great savings can be obtained by the use of submerged combustion. However, in a steel mill where the steam production is much greater than that required by pickling baths, where mechanical agitation is provided and where steam condensation is of little consequence, submerged combustion might have a difficult time competing with steam heating.

EFFECT of Rate of OPERATION in the COKE PLANT

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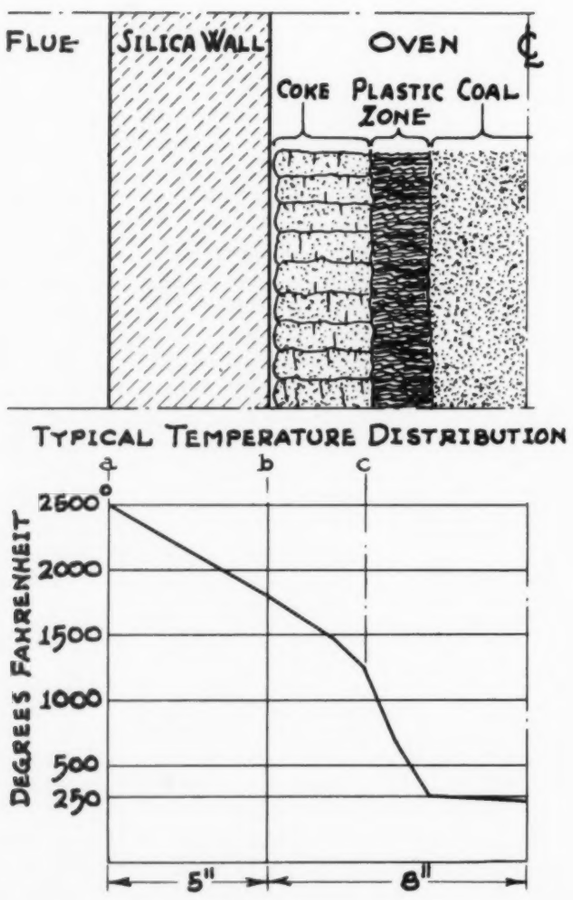
Figure 1 — Schematic drawing showing temperature conditions in oven during carbonization.



Change in rate of operation of the coke oven plant manufacturing furnace coke for the blast-furnace plant is incidental to variation of blast-furnace operation. Since the latter is directly tied up to iron and steel production, constant rate of coke production cannot well be expected at all times. In this respect the coke plant producing gas for utilities or coke for domestic use is in a radically different position. Its rate of operation can often be maintained constant over periods of many years.

Given a coke plant with a certain number of ovens, there will be a definite limit to the coke producing capacity, determined by the rate of coking of the individual ovens and their capacity. In time of maximum production, this limit is readily reached. The maximum allowable coking rate is primarily determined by the maximum allowable heating flue temperatures and can sometimes be modified by the coal mixture used. It should be kept in mind that expansion tendencies of coal become aggravated with more rapid coking rate. Also, coke made from coal at rapid rates frequently has less desirable characteristics.

If satisfactorily contracting coals are used, it is sometimes possible to increase the coke producing capacity of individual ovens by adding small amounts of oil to the coal, thereby increasing its volume weight. (Ramsburg and McGurl, A.G.A. Proceedings 1940).

At shortest coking times, the coke oven batteries, coal and coke handling apparatus, as well as by-product recovery plant, are expected to be loaded to capacity. During periods of peak production, all of the plant thus should come up to requirements relatively seldom put to it. During such periods, the benefits of good maintenance during previous slack periods are fully realized and a policy of providing the coke plant with spare capacity bears abundant fruit.

With decrease in coke demand, there are several ways open to the coke plant to effect lower production. Decreases down to 60 or 70 per cent of capacity are usually made by lengthening the coking time of the batteries. Operation at still lower rates such as became common practice in many plants during the past ten years is accomplished in various ways peculiar to the set-up of the plant in question. Larger coke plants usually take one or more batteries out of operation, either banking

them or cooling them down, while maintaining reasonably fast coking rates in the other batteries. This procedure has the outstanding advantage of lowering operating cost and maintenance on several units. Plants with only one battery are known to have gone to coking times of as much as seven days with reduced operating crews.

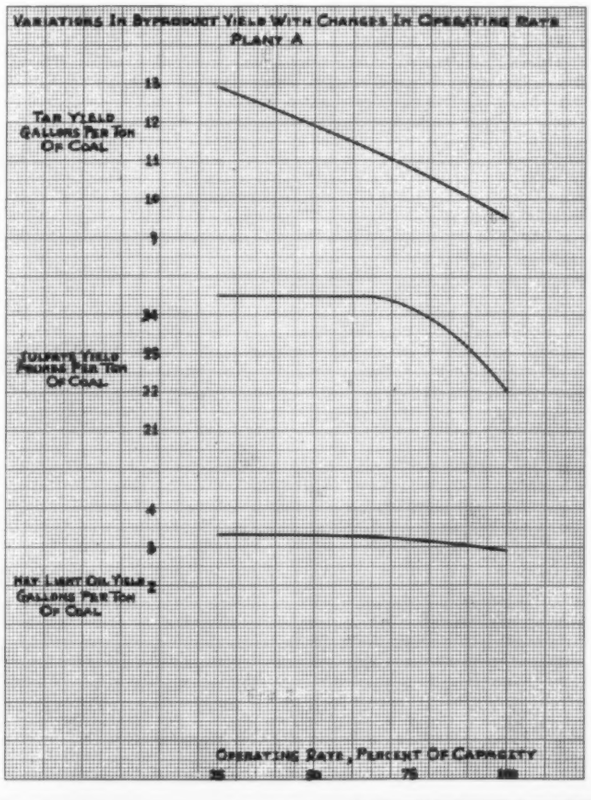
In deciding about the procedure for slow coke production, cost and quality of the coke are naturally prime objects of consideration. While the ideal of every operating man is to have a constant, low conversion cost figure, it is obvious that certain unavoidable constant overhead expenses are there to cause a rise in unit costs during slack periods. Also, slow and variable operating rates necessitate at least normal oven maintenance, especially patching, in order to keep the brick structures in good condition. To strike the right balance between the desire for low unit cost and the desire for a wise maintenance policy in slack periods is the problem of outstanding importance for a coke plant operator. Further curtailment of operations may finally approach the point where a decision is to be made between keeping one or more batteries hot without pushing or letting it cool down.

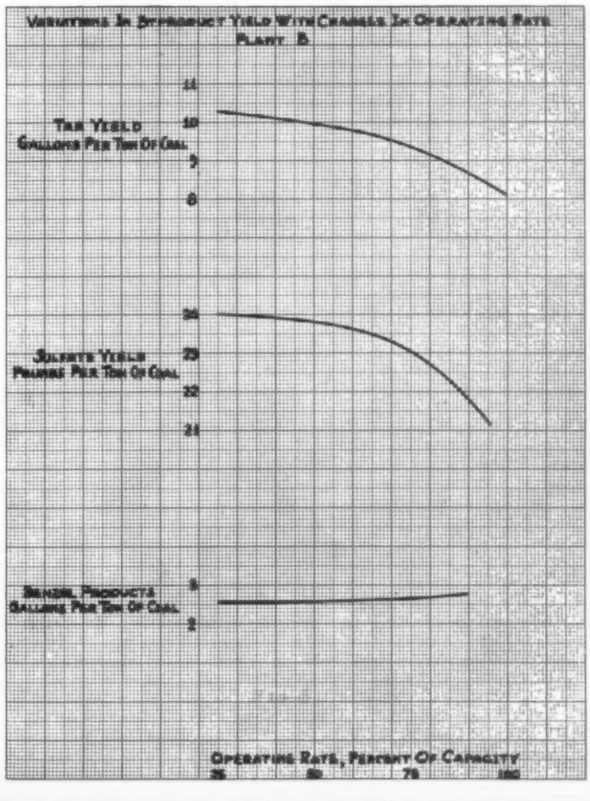
A number of specific effects of operating rate on coke-plant results, the quality, the yield and the cost of the products, and on coke-plant condition, will now be discussed. Owing to the fact that varying plant conditions and varying coal types are affected indifferent manners by the operating rate, this discussion is bound to be more an enumeration of generalities rather than a development of a specific case.

Coke and By-Product Quality

Changes in quality of product made by carbonization in coke ovens can be traced back to changed carbonization conditions. It is therefore well to consider briefly to what extent the physical condition of the ovens is affected by changed coking rate. Figure 1 shows a schematic drawing of flue and oven during carbonization. Heat is supplied in the flue by gas combustion, and is transmitted through the silica wall by conduction. The total amount of heat supplied per hour varies in direct proportion with the rate of carbonization; twice as much heat is required for double the coking rate or half the coking time. The temperature difference a-b constitutes the temperature gradient required to force the heat through the wall, it is proportional to the coking rate. A common value of this gradient at a coking rate of slightly over one inch per hour is about 700 F, with a temperature of the wall of 2500 F on the flue side,

Figures 2 and 3 — Charts showing variations in by-product yields with operating rates in typical Pittsburgh district plants.





1800 F on the oven side. Further pursuing the heat flow and realizing that the initially formed coke is practically loose from the wall, except for point-contact we find that heat is transmitted from wall to coke largely by radiation, thence through the coke layer up to the plastic zone by radiation and conduction both. This process takes place under the driving force of a temperature gradient from b to c of some 600 F. At temperature c, a rapid drop in temperature sets in and at this point is the approximate limit of the so-called plastic zone. This zone travels from wall to center of oven and separates the more or less finished coke from the uncarbonized coal; in it, the carbonization reaction takes place, viz. coal becomes plastic, evolves gas, the plastic mass solidifies and sets up as solid coke. With a temperature of little above the boiling point of water, 212 F, on the coal side, a temperature of some 1000 F on the coke side, the plastic zone constitutes the barrier in which the heat introduced through the oven walls is almost completely absorbed. Relatively little heat is transmitted across the plastic layer, practically all heat for carbonization is consumed at the outer side of the plastic layer in heating up the solid residue of carbonization to the coke temperature. Besides the heat-flow from the oven wall inward by radiation and conduction, a reverse heat-flow by convection takes place simultaneously, due to gases liberated from the plastic layer flowing against the said heat-flow. These gases carry sensible heat away from the entire path they follow through the coke, are partly changed chemically during their travel through the hot coke by a cracking of the gas and graphite deposition on previously formed coke. This cracking continues during the travel of the gas along the hot wall on its way out of the oven. Only a small part of the gas with the water vapor from the coal moisture is evolved on the coal side of the plastic zone and travels up through the coal charge when coking fine coal as is the usual practice.

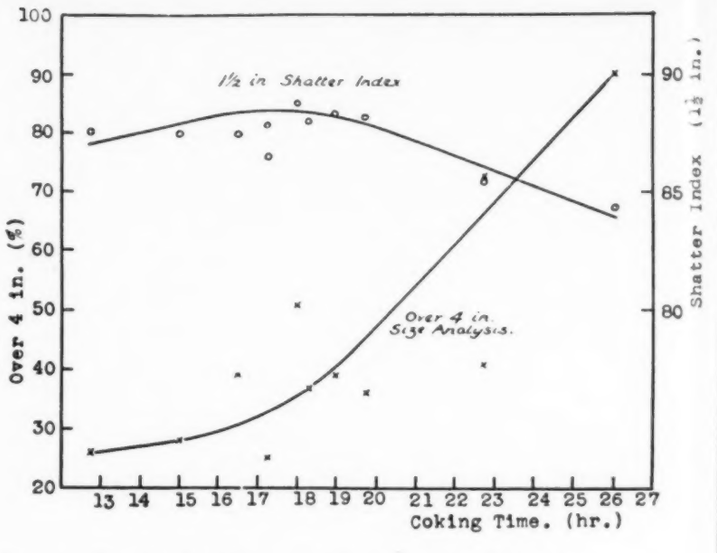


Figure 4 — Chart showing effect of coking time on yields and strengths of cokes from English coals.

B. J. C. VAN DER HOEVEN

Change in coking rate means change in rate of displacement of plastic layer by changed supply of heat thereto. Such a condition is brought about by lowered flue temperature, lowered temperature gradients through the wall itself as well as through the coke. For a coking rate of about one-half of that of the example given above, the temperature might be for a, b, and c, respectively, 1850 F, 1500 F, 1200 F. Such a change means:

1. Lower wall and coke temperature.
2. Slower rate of decomposition of the plastic mass.
3. Longer period of standing over of coke.

The decreased temperature of coke results in decreased cracking of gases, with consequent appearance of more primary (low temperature) components in the gas, such as long chain paraffins. It cuts down the graphite depsotition on the coke formed, and allows more time for recrystallization of the coke. Due to slower gas evolution from the viscous plastic layer, there is a tendency for formation of larger, more blocky coke pieces at long coking time, the stresses and strains occurring in the plastic layer are generally less intensive. Expansion tendencies of the coal are likewise diminished at long coking time. Complication can, however, enter this picture often caused by unusual relative position of the temperature curves of plasticity and gasification.

It might be added that slow coking rate does not necessarily mean cooler coke if the coke is left in the oven longer than is strictly required for the removal of gas.

Briefly summarized slower coking rate gives coke of larger size, blockier, more silvery in appearance, often stronger; gas and by-products, containing more low temperature constituents; light oil high in paraffins,

higher tar yield, high in tar acids, somewhat higher ammonia yield; typical cracking products such as naphthalene and wall carbon are produced to a lesser extent at slow rates. The light oil constituents of mixed paraffin-aromatic nature, toluene, xylene and solvents, are more abundant at low coking rates; at fast coking rates they are partly replaced by benzene. Fast coking time produces more pyridine.

Yields

Some typical figures on variation of yields of tar, sulphate and light oil with coking time are given in Figures 2 and 3. These figures from two representative Pittsburgh district plants show relatively little change between such extremes as 30 to 100 per cent of maximum operating rate which includes coking times of as high as 50 hours. The most pronounced change is a 25 per cent increase in tar yield at slow coking time, a 15 per cent increase in sulphate yield. These figures may indicate a general trend, but they should be accepted with a great deal of reserve and may not represent an average picture. Every coke plant operator will agree that secondary factors enter into the yield picture, in many cases to such an extent that the final result is extemely confused:

1. Lack of adequate by-product capacity at high operating rates may lower the actual yields.
2. At slow operating rates the coal mixture may be different due to total or partial elimination of the higher priced component of the coal mixture, advantage being taken of naturally higher strength of the long coking-time product. More or less stock coal may be used.
3. At slow general operating rates, not all batteries may run at the same rate.

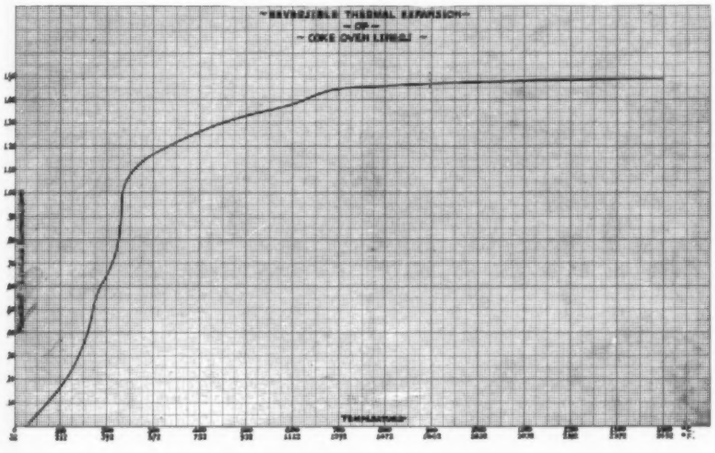


Figure 5 — Expansion curve of silica brick.

The total gas yield per ton of coal does not vary substantially with moderate changes in coking time. The underfiring gas requirement of the oven battery will vary with coking time, and the relation is influenced by operating conditions. Moderate changes in operating rate down to 60 per cent of maximum capacity do not affect underfiring very much. Two factors with opposite effect are involved in this relationship; on one hand, slower rate gives better regeneration of waste heat, less cracking of hydrocarbons, lower coke temperature, all of which tends to lower the underfiring, on the other hand at a slower rate of coking the radiation loss from the battery is not cut down in proportion. The final result is that for moderate decrease in rate of operation the underfiring is slightly lower than at maximum rate. Drastic lowering of operating rate to 30 per cent or less of maximum will cause a distinct increase in underfiring requirement and consequently lower the surplus gas production.

Even if coke yields and gas yields would show a tendency to variation with coking time, this tendency is compensated for by the use of different coal mixtures and a clear picture is hardly ever obtained. In the past ten years a great deal of experimental work has been done in this country and abroad on the yields of product obtained at different coking temperatures from various coals, (Bureau of Mines Monograph No. 5, 1934) and the interpretation of such yields on the basis of coal analysis (Lowry, Landau and Naugle, A.I.M.E. Meeting February 1941). Although this work is extremely interesting the fact that all of it was done on a small small scale requires that the interpretation of the results in terms of plant conditions should only be made with proper discretion.

Figure 4 shows the effect of coking time on the yields and strengths of cokes from English coals. (Data from Mott and Wheeler 1939).

Plant Conditions

Ovens—Change in coking rate is brought about by variation of flue temperature. Whereas a flue temperature (measured on the airport brick 15 minutes after reverse) of some 2500 F is required to give a coking rate of one inch per hour, the flue temperature for half that rate would be around 1900 F. Oven wall temperatures are lowered in proportion. Fortunately, the expansion curve of silica brick (Figure 5) is practically flat in the range from 1600 to 2600 F, hence the expansion and contraction of the oven walls is small enough during such changes to allow the brick structure to standup without cracking. Even when translated to a 40-foot long oven wall the movement will only be of the order of 0.1 in. per 1000F. At the same time it is obvious that the ends of the oven walls will be at distinctly lower temperatures and within or close to critical expansion ranges. During a slow-down, change of nozzles in end flues is advisable to maintain sufficiently high temperature in these flues. Reversible contractions with resultant cracks may appear near the ends loosening up joints and patching material. Therefore, during periods of slowing down, care must be taken to continue proper side support of the brickwork; specifically, by taking up on cross tie-rods as is needed to keep a strain on the buckstays. Such a strain should always be exerted on the oven wall from oven-floor to oven-roof and not be taken up on the top pavement of the battery alone. In other words, the top of the buckstay should barely touch the top edge of the brickwork. Cases are shown where the

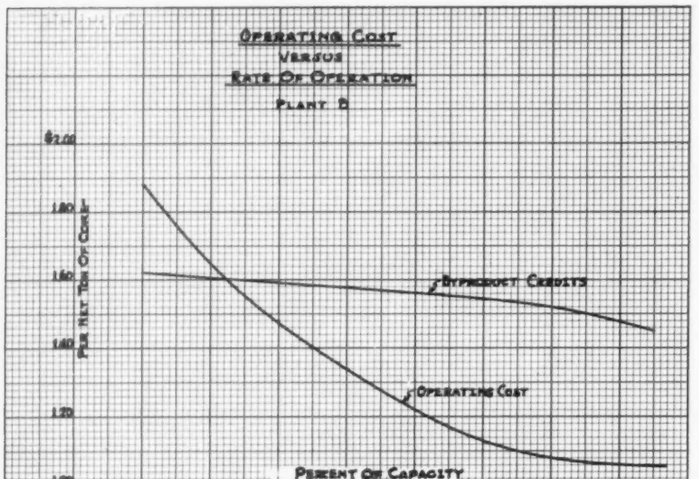


Figure 6 — Curves showing operating cost and by-product credits with varying rate of operation.

fully followed up, radical changes in coking time always are somewhat of a strain on the brick structure and should be avoided if possible. It is generally advisable to make changes in coking rate relatively slowly, a reasonable maximum rate of change would be 3 per cent of the maximum operating rate per day. Even under the best of conditions, it may be asserted that banking of a battery shortens its life by a year and sometimes more. Patching schedules should be strictly followed in such periods; jamb patching hardly ever survives a cycle of up and down operation. Sufficient back pressure should be kept on the oven in slow, as well as fast, coking time to keep the brickwork sealed up.

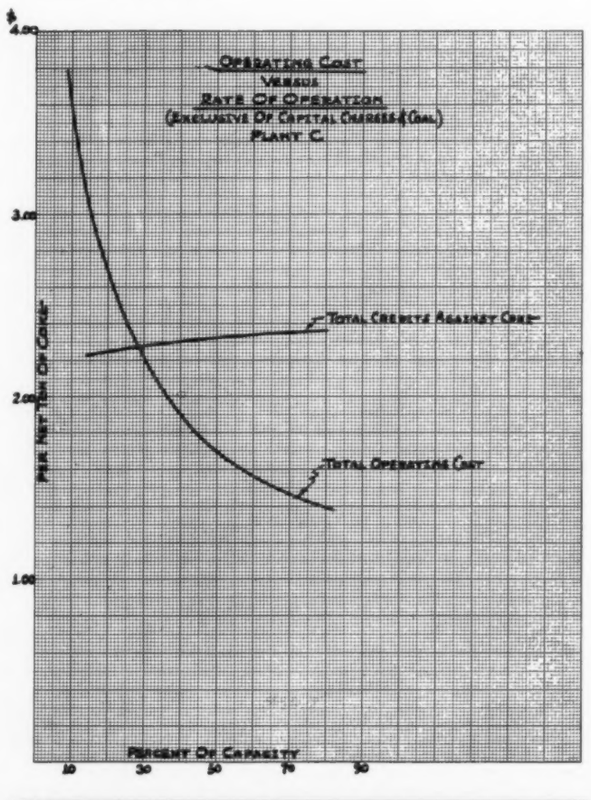
The mechanics of adjusting heats in a battery to radical changes in coking time vary with the heating system provided. For very slow coking times in gun-flue batteries, it is found advantageous to dilute the oven gas in order to obtain better vertical heat distribution in the flues and so avoid black tops; for extremely slow coking rates or for banked batteries, it has been found practical to use blue gas, producer gas or even blast furnace gas in the gun flues. The air-flow to the battery should naturally be reduced by using sufficient finger bars or orifices in the air boxes to give a reasonably good combustion. If no gas dilution is practical, it is preferable to use a higher gas pressure on the guns for short periods

upper brick work of the battery hung up on the buckstays during a period of rapid contraction of the battery. The height of the battery likewise varies slightly with change in coking time and nothing should interfere with this movement. With proper precautions a tight structure can be maintained; if no support is given to the brickwork, small cracks and joints may open up, become filled with carbon and gradually grow in size. Numbers of cases of distorted brickwork have thus been brought about. The use of springs on buckstays has aided materially in affording continuous support to brickwork. Spring tension should be periodically checked by measuring the length of the spring. Springs should be protected from excessive heat and occasionally tested for their load-bearing capacity.

Other locations in the battery requiring attention, during slow operation and the more so during banking, are gas-gun structure, regenerator faces and walls. In part, these structures are within the critical temperature range and tend to move appreciably with variations in temperature. The tendency to movement of regenerator walls during variations in operating rate is limited by the concrete mat on which the battery is built. Consequently, vertical cracks tend to develop in regenerator walls, usually near to the ends where the movement is greatest. During the heating-up and initial months of operation of the battery, the mat heats up and undergoes expansion; in turn it heats up the soil adjacent to it and constitutes a heat reservoir which does not follow rapid changes in operating temperatures. As a result, cracks may develop in the mat iteslf during heating and cooling cycles, excessive strains develop in adjacent silica structures. More recent constructions designed for underjet heating employ mats with expansion joints, freely supported by columns. Such mats can follow temperature changes more readily.

Even assuming that the above suggestions are faith-

Figure 7 — Curves showing operating cost and credits of another plant with varying operation.



say for five or ten minutes during every thirty minute reverse period rather than reduce the gas pressure indiscriminately. If this is done, however, care should be taken to have sufficient suction on the flue system of the battery during the gas-off period to prevent flow of waste gas from flue to oven. Another advantage of burning gas for short periods at a higher rate is the possibility of obtaining better air distribution in the flues.

The adjustment of heats at slow coking rate is materially simplified by the features of underjet batteries. Individual adjustments for the flues are more readily possible.

As much as it is essential during fast operation of a coke oven battery to inspect heats and avoid flue temperatures of 2750 F, and higher, it is essential during slow operation to avoid cooling of silica brickwork above the regenerator walls to below 1600 F. Repeated experience with cracked gun blocks, leaky guns, etc., has emphasized this point. It should be kept in mind that with 1600 F airport temperatures parts of the essential structure may be at temperatures as low as 1200 F and approach critical conversion temperatures.

A few words might be added about so-called banking of batteries, i.e. keeping them hot without pushing coke. Usually and preferably all coke is pushed out prior to banking in order to prevent slow combustion of oven contents with ensuing ash production and attack of silica walls.

In empty ovens, all carbon will naturally burn out of brickwork joints and cracks, and extensive patching has to precede a resumption of operation. All openings to the ovens, doors, lids, etc., should be sealed to perfection to prevent heat losses and consequent excessive cooling. For the purpose of heat economy, insulation may be applied to the top of the ovens and the inside faces of the doors. In this respect a compromise must always be made between heat loss and loss of strength. Essential reinforcing elements of the battery, such as buckstays, tie rods, and door frames, should never be covered with insulation enough to cause them to overheat.

Heat requirements for banked batteries depend on the care used in insulating them. A good value for a well insulated battery is about 4 million Btu per oven per day.

It is obvious that successful banking of a battery is by no means simple, and should be carefully prepared and executed.

The extreme of slow operation, cooling down of the battery, has been discussed in detail by several authors: B. M. Livezey, Eng. Soc. W. Penns., December 1933; H. W. Seyler, A.G.A. Production Conf., May 1939 and L. E. Knowlton, A.G.A. Production Conf., May 1939, and is somewhat beyond the scope of this discussion. It is obvious that this drastic step should be well considered, it shortens the useful life of any silica structure by several years.

By-Product Plant—Rate of operation of the coke plant affects the by-product recovery apparatus much less than the oven battery. Usually the by-product equipment is subdivided into several units, one or more of which can readily be taken out of operation during slack periods. By doing this a saving in operating costs as well as labor is obtained and the desirability of having multiple unit operation in the by-product plant is thereby emphasized.

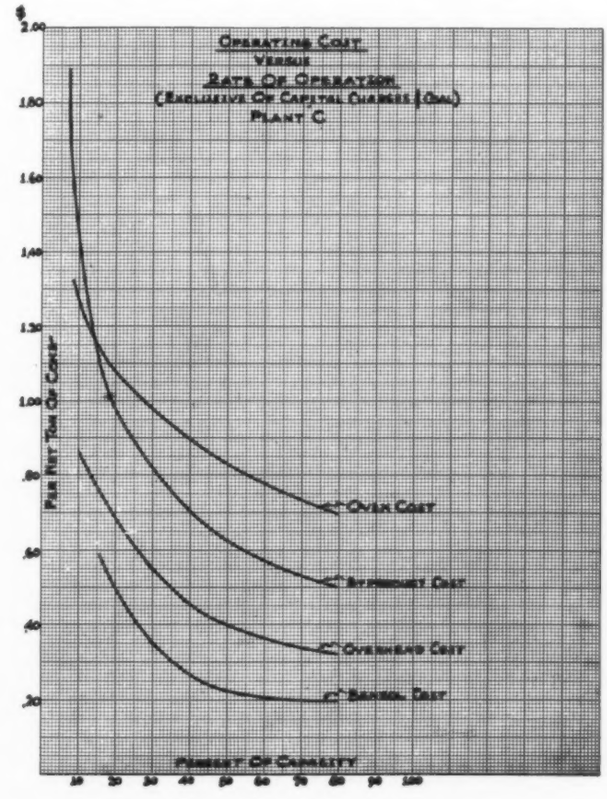
During slow operation units are frequently underloaded. Temperature conditions are hard to maintain. Outside equipment, such as final coolers and light oil scrubbers, when under light load, may get much too cold in winter weather causing trouble in the light-oil plant. This situation can be remedied by recirculation or heat input. Light loads cause poor distribution of scrubbing media over scrubbers and should be compensated for by adjustment of distribution nozzles.

Certain types of tubular equipment are subject to accelerated corrosion when taken out of operation due to infiltration of air. Particular care should be taken with such equipment during shutdowns.

Costs—Figures 6, 7, and 8 show the variation in plant operating cost with rate of operation for two typical coke plants, B having several batteries, C with one battery of ovens. Although such figures are very much dependent on accounting practices and not readily comparable between different plants some observations of general interest can be made.

There is little difference in slope between cost curves for B and C: the ratio of cost between 80 per cent and

Figure 8 — Curves showing various operating costs with varying rate of operation.



40 per cent operation is in both cases 1:1.36, individual differences between costs are due to local labor and accounting differences. Comparing the slopes of oven, by-product and benzol cost curves it is evident that the latter two run up faster with lowered operating rate. At the ovens where the number of men employed is larger, reductions in force can more readily be made In the by-product plant, the steam consumption of major operating units, such as exhausters and pumps, cannot be reduced in proportion to the volume pumped. It is obvious that at slow operating rates benzol operation becomes unprofitable.

DISCUSSION

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B. J. C. VAN DER HOEVEN, General Superintendent, Engineering and Construction Division, Koppers Company, Pittsburgh, Pennsylvania

H. V. LAUER, Superintendent, Coke Plant, Carnegie-Illinois Steel Corporation, Joliet, Illinois

W. T. BROWN: Mr. van der Hoeven is to be complimented on his fine handling of a difficult subject, particularly at a time when the steel industry is doing everything possible to increase coke capacity.

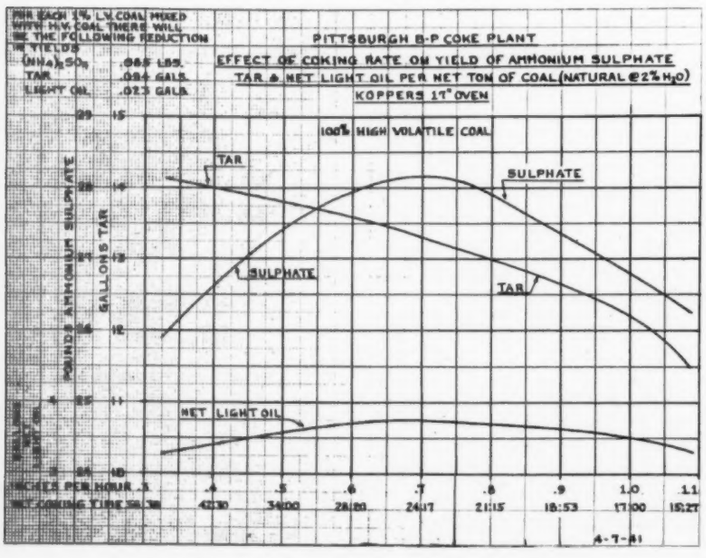
I would like to discuss two important effects of change in rate of operation in the coke plant — namely, the effect on blast furnace coke quality and the effect on yield of by-products.

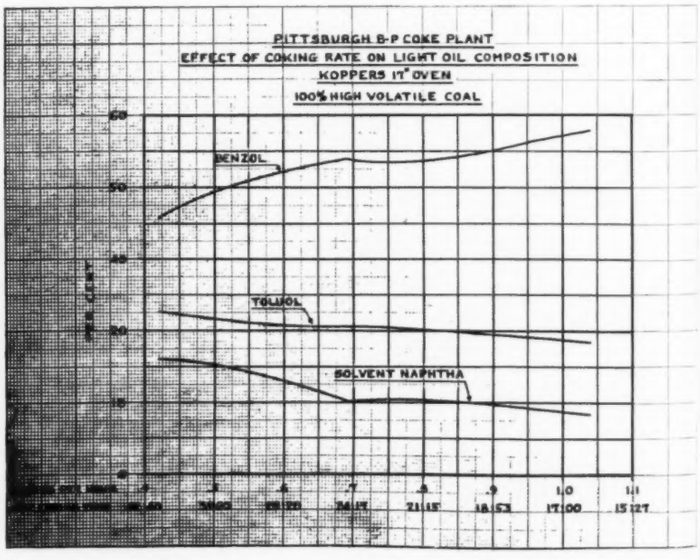
The main requirement for good blast furnace coke is uniformity — uniformity of size, structure, ash and sulphur. Any change in rate of operation, flue temperatures, or coal mix charged to the coke ovens, changes the quality of the coke. Any change in quality of coke, whether improved or degraded, has a bad effect on the blast furnaces until the proper adjustments are made to use this particular fuel.

Most coke plants use the same coal or coal mixture on all rates of coke oven operations. All coals have different carbonizing and expansion properties, and produce good blast furnace coke at a certain temperature range. Coals or coal blends that do not damage the brick side-walls of the coke ovens at long coking time, may be very dangerous on fast coking time, due to the expanding properties of the coal or coal mix. Pocahontas low volatile coal varies from no expansion to as much as 25 per cent expansion. I have found variations in one mine in the Upper Kittanning seam where the coal expansion varied from 2.5 to 27 per cent.

Better knowledge of the coals you charge to your coke ovens is very important, if you wish to produce good blast furnace coke at both slow and fast coking time and not damage your coke ovens.

The coke in a blast furnace not only acts as the fuel, but it must support and distribute the burden and flux, and act as a bed of broken solids





for proper distribution of the reducing gases. Therefore, uniformity of size, is of prime importance. At slow coking time you produce large blocky coke and on fast coking time you produce small sized coke with many cross fractures. The proper sizing of coke is necessary for good blast furnace operation.

Mr. van der Hoeven has shown the effects of change in coke operation on by-products in his paper, but I would like to present two slides prepared by Mr. R. W. Campbell, superintendent of the Pittsburgh coke plant of Jones & Laughlin Steel Corporation. These figures are actual yields covering a period of 22 years, from June, 1919 to April, 1941 and clearly show the effect of changes in rate of operation on by-product yields, using 100 per cent high volatile coal and the effect of each one per cent of low volatile coal in the mix. The coking rate is shown both in time and inches per hour for 17 in ovens.

1. Light oil showed a maximum yield of 3.5 gallons per ton at 24 hours coking time and dropped as the coking time was increased or decreased.
2. Tar yield showed a rapid increase as the coking time was decreased, from 11.5 gal to 14.1 gal per net ton.
3. Ammonium sulphate followed the light oil curve showing a maximum yield of 28.2 pounds per net ton at 24 hours coking time and decreased on longer or shorter coking time.
4. The per cent of benzol was rapidly increased as the coking rate became faster at the expense of the toluol and solvent naphtha.

At fast coking time more naphthalene, pyridine, picoline, cyanogen and carbon disulphide are produced than on long coking time, in fact these constituents practically disappear on long coking time.

The greatest volume of coke oven gas is produced at fast coking time and rapidly decreases as coking time is increased but the heating value is the reverse — the longer the coke time, the higher the Btu value due to the increase of methane and less hydrogen in the gas.

M. D. WALD: Mr. van der Hoeven has dealt in a general way with the changes in conditions and results brought about by varying rates of operation in the coke plant. His discussion of the factors that limit the coke producing capacity of the ovens is particularly timely. The statement that "the maximum allowable coking rate is primarily determined by the maximum allowable heating flue temperatures, and can sometimes be modified by the coal mixture used" is important in view of the acute coke shortage at the present time. Our own experience bears out this statement. Recently we increased the percentage of low volatile in our coal mix from 23 to 35 per cent in order to increase our coke production. The coke from the new mix was much more easily and uniformly heated, and average flue temperatures dropped 35 F. This was in 18¼ in. wide ovens, using Pennsylvania high volatile and West Virginia low volatile, and operating at a coking rate of 1.24 inches per hour.

At the other extreme of operation, i.e., when ovens are banked, the heat requirement of 4 million Btu per oven per day given by Mr. van derHoeven would seem low. Such low heat supply would necessitate very thorough insulation of the battery. Flue temperatures of 1600 F, measured on the airport brick, are scarcely sufficient to prevent cooling of the upper part of the ovens below the danger point. With somewhat higher temperatures, say 1800 F, there should be practically no damage to the oven structure during banking.

The variations in yield of tar and ammonia shown by Mr. van der Hoeven are about the same as we have experienced. In benzol products, however, we have found the variation much greater. Our yield of saleable products generally varies from about 2.8 gal per ton of coal at 50 per cent operation to about 3.3 gal per ton at full capacity, this in spite of the fact that the percentage of low volatile is much higher at the faster coking rate.

We have some data also on the variation in yield of pyridine bases. As Mr. van der Hoeven has pointed out, the yield of bases increases with increasing coking rates. We have found the variation to be from .144 lb of finished bases per ton of coal at 30 hr coking time to .211 lb at 15.5 hr coking time.

W. H. COLLISON: The general trends indicated by Mr. van der Hoeven's curves for yields of by-products and for costs, I believe, are correct. I think the point should be made very distinct that the characteristics of the coals entering the mix exert considerable influence on coke quality and by-products with varying operation rates. Mention was made that coke on fast schedule is frequently inferior to coke on lower schedule. It has been our experience with a mix containing considerable quantities of southern coals that coke quality as indicated by blast furnace practice, is higher at higher operating rates; that is, coking rates of .9 to 1.1 in. per hour. This better coke quality is not indicated by shatter tests, tumbler tests or coke size.

WILLIAM R. PENDRY: Mr. van der Hoeven's paper seems to express my thoughts. Of course it is preferable to hold ovens hot rather than let them go cold. One thing seldom touched on is whether to push them empty or leave the coke in. I am inclined to leave it in.

We took a battery off in May, 1931, and pushed it in March, 1932. There was no coke left when it was pushed and opening it up was a mistake. The gas required for keeping it hot increased materially after the ovens were cleaned out.

We are doing a pretty good job with old ovens put into operation between April and October, 1918. All have been cold from four to seven years during that period.

We are now operating at capacity at 14¼ hour coking time, charging about 3900 tons of coal per day and producing 2800 tons of furnace coke which the furnaces seem to be pretty well satisfied with.

I may add that our ovens are 18¼ in. average width and have 4 in. taper, 1½ in. more than the usual. The economics of the procedure should be weighed very carefully before allowing a battery to go cold.

C. P. BETZ: There is one question I would like to ask Mr. van der Hoeven, which has caused us concern. I don't think we have to anticipate any shutting down or slowing down of our coke ovens at the present time due to lack of orders, but we are confronted daily with the possibilities of a quick shutdown due to labor conditions.

The thing that has caused us concern is, What should we do if we are confronted with the above condition to safeguard the knife edges and door frames on ovens equipped with self-sealing doors?

B. J. C. VAN DER HOEVEN: I don't think there is any reason to

(*Please turn to page 113*)

OXY-ACETYLENE

Defense Developments

By J. H. Zimmerman

DEVELOPMENT MANAGER

THE LINDE AIR PRODUCTS CO.

NEW YORK, NEW YORK

Presented before A. I. S. E. ANNUAL CONVENTION
Cleveland, Ohio

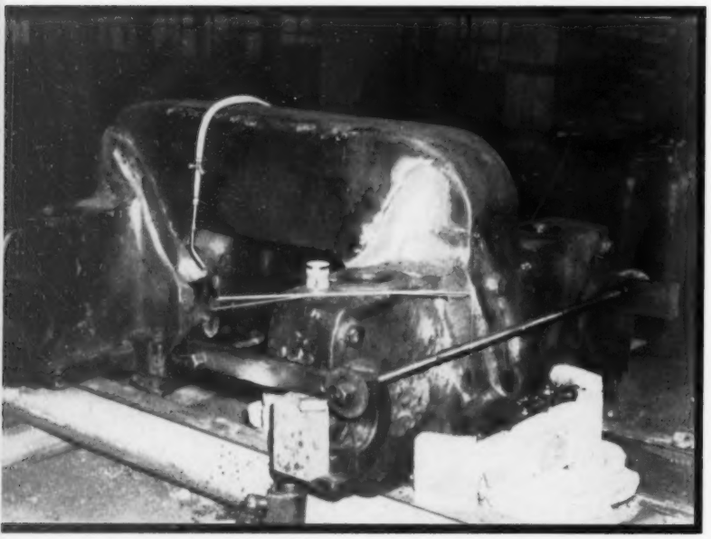


Figure 1 — Almost 400 lb. of bronze were required to complete the repair of this 13-ton cap casting. Savings of considerable time and money were achieved.

Figure 2 — This is a general view of the 44 in. diameter cylinder of one of the former Axis ships undergoing repair by bronze welding.

▲ Developments in the oxy-acetylene field have been accelerated to a marked extent during the past two years as a result of the broad industrial demands of the defense program. The old welding and cutting processes have been pressed into new fields, and new uses for the oxy-acetylene flame and the cutting-oxygen stream have been, and are being, achieved. Moreover, concurrent with the widened and intensified scope of application of the processes, new developments have been brought about in apparatus, machines and gas-handling equipment. The more important current oxy-acetylene developments of interest to the steel industry and of consequent importance as a part of the national defense program are described briefly in the following paragraphs.

Maintenance

The earliest yet most persistent uses of the welding and cutting blowpipes have been in the general field of maintenance and repair in the heavy industries, particularly in the steel mills. It seems unnecessary to cite the numerous every day operations involved in the repair of broken machinery, the renewal of worn parts, the installation of structures, machines and piping, the alteration of equipment and the demolition and scrapping of useless items. However, it is important to note that these old and familiar applications are certainly of greater importance today than ever before.

Full-capacity operations and the accompanying lack of stand-by equipment have seriously multiplied the problems of maintenance. Shortages and slow deliveries of heavy equipment have prompted efforts to alter and render serviceable every possible unit of obsolete machinery. Scrap piles are being closely combed and

salvaging operations are at a peak. The oxy-acetylene processes, through their simplicity and versatility, are found to be increasingly helpful in all of these emergency measures.

A typical quick repair job is illustrated in Figure 1. This heavy casting was bronze-welded and put back in service in a matter of hours, whereas the shutdown involved in waiting for a new replacement casting would have been a matter of weeks. Another interesting salvaging job is shown in Figure 2. Bronze-welding again was employed in the repair of the sabotage damage done to the engine of a confiscated Axis ship.

Billet Cutting

The flame-cutting of billets, blooms, slabs and ingots, either hot or cold, has been going on for many years, but acute defense demands for high-production cut-off equipment have led to the development of new principles and new machines. These new requirements for oxy-acetylene cutting originate to some extent through an insufficiency of mill shears and saws, but they are equally due to improvements in the flexibility and adaptability of cutting equipment and increased speed and economy of the process.

The oldest method of production cutting of cold billets involves the use of the portable straight-line type of cutting machine operating from a track bridging over or resting on a row of billets bedded side by side. The movement of the cutting blowpipe is continuous and preheating is usually accomplished by means of an auxiliary heating operation. An example of this procedure is shown in Figure 3 in which the next to the last billet of a long row is being cut, and the last billet is being preheated, so that the cut will pick up with no hesitation on the forward movement of the machine. With the completion of the last cut the track is rolled to the next cut-off position and another batch of forging slugs is cut from the billets. The same treatment can be applied to rounds.

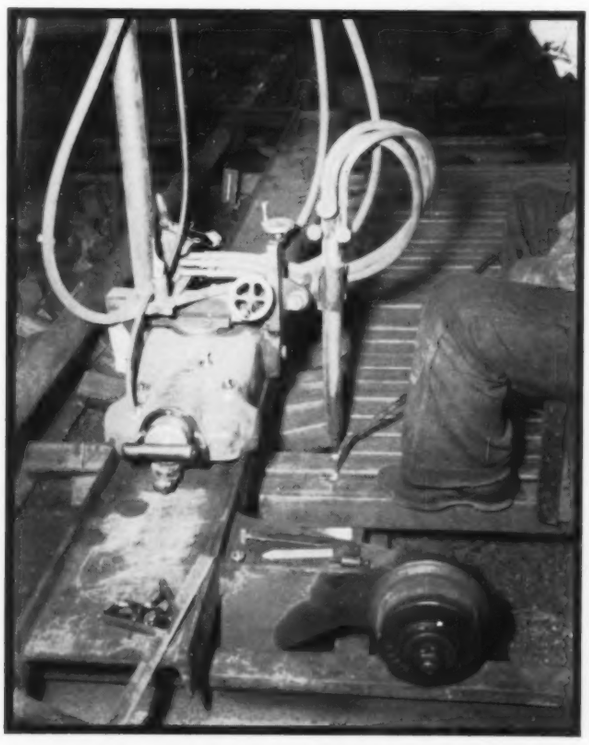


Figure 3 — The continuous cutting on these shell forging slugs was done with a straight-line cutting machine with manual preheat.

Another convenient and accurate method of cutting cold billets to length is illustrated in Figure 4. A portable spring-driven, hydraulically governed billet-cutting machine is squared against the billet at the cutting location, cocked to the starting position and released for the automatically controlled cutting movement after preheating. In cutting square billets, this type of machine imparts a swinging motion to the blowpipe, from a lagging angle at the beginning of the cut, to facilitate quick starting, to a leading angle at the finish, to insure "dropped" cuts when the machine is operating with high lag at the most economical high speeds. The design of this machine provides for the maintenance of a fixed distance between the nozzle and the billet throughout the swinging movement along the cut. By a simple adjustment the machine can be adapted to the cutting of rounds, and in this operation the blowpipe remains vertical and the fixed distance between nozzle and work is maintained automatically, with no swinging required. The advantages of this type of machine lie in the portability, accuracy of control and absence of power lines. One machine of this type recently made 790 cuts of 3½ in. gothic squares in an 8 hr turn with one operator.

An example of hot-cutting, in the roll line, is shown in Figure 5. In this operation the hot billets are transferred from the billet mill to a runout table where they are stopped and pushed to position for cutting. Water-cooled blowpipes are supported by counterweighted extension arms pivoted on the tops of portable cutting machines which provide the required cutting movement.

A number of variations of this general type of cutting setup have been devised for installation in a number of mills. Fully automatic machines operating on this same principle have been developed for the cutting of hot round or square billets and slabs. In these machines the operator starts the cutting operation by a push button, and all remaining steps in the cycle from the lighting of the preheats to the retraction of the blowpipe after the cut are controlled automatically. Machines of this type may be used in multiple, and are mounted on tracks parallel with the table, the number of units required being determined by the cutting and rolling schedules. Adjustment for length can be obtained by manual positioning of the machines with respect to a stop, but all cuts can be handled simultaneously and automatically from a single control pulpit.

Shell-forging-slug-cutting requirements have led to the development of the multiple swinging-blowpipe type of cut-off machine shown in Figure 6. The control of this unit is accomplished by the simple rotation of a sequence switch, and the cutting blowpipes assembled to the mounting bar operate in unison. The number of cuts that may be made simultaneously with a machine of this type is largely dependent upon the camber of

the billets being cut. Installations carrying five blowpipes on 14 in. centers are performing satisfactorily.

Machines of this type may also be adjusted to do multiple nicking or alternate nicking and cutting. Flame-cut slugs are preferred by many forging plants as opposed to those produced by the nick-breaking procedure. The smooth square ends do not meander from the line of cut, and there is no overfilling or underfilling or underfilling of the dies, in subsequent operations. It is also reported, that the scale condition developed in the heating furnace on the flame-cut ends, is preferable to that developed on fractured ends. The requirement for individual nick-break inspection of shell forging slugs has been superseded to some extent, by etch inspections at prescribed intervals, with no further check, when these are satisfactory. It is believed by some, that, on secondary pipe in forging billets, a reliable inspection can be made by visual examination of the surface of the oxy-acetylene cut itself. Experimental work has been started, toward the establishment of the reliability of this method.

Plate Cutting

The defense program has not only stimulated the trimming, shaping and beveling of plates by oxy-acetylene cutting in shipyards and fabricating shops, but the limitations of the various contractors have made it necessary that a considerable amount of plate trimming and, in some instances, beveling to close tolerances, be undertaken by the steelmakers. Accurately trimmed and squared plates have been prepared by a number of steel companies in the past, but the new requirements have multiplied the need for this service to an appreciable degree.

The flexibilities of the oxy-acetylene cutting process have rendered it adaptable to a great many of the shipbuilders' problems, and the process is playing a vital part in the accelerated construction program in both old and new yards. While a great deal of cutting has been done in shipyards in the past, it was, until a few years ago, considered necessary to use planers, to prepare accurate edges for welding. With the growth of the shipbuilding programs, existing planers were found to be entirely inadequate, and a demand arose for oxy-acetylene cutting equipment which could be used to produce prepared edges, to the required tolerances. Such equipment has been developed and is in wide use in shipyards today. This same type of equipment has been adopted by a number of steel fabricating plants.

Figure 4 — This shows a portable spring-driven, hydraulically controlled billet cut-off machine in operation.

The principal feature of the most recently developed types of plate-edging devices is the so-called riding or floating support for the cutting blowpipe. As the tracks on which the straight-line cutting machines are mounted, are straight and level, it becomes necessary to provide a floating feature, in order to compensate for waves and buckles in large-area plates, and so provide for a constant distance between nozzle and plate, throughout the length of a long cut.

A number of types of accurate track installations have been devised to fit in with the various types of plate-handling equipment. A typical example of an installation which has proved to be satisfactory, is shown in Figure 7. While this equipment has been developed primarily for the cutting of ship plate, it is, of course, equally applicable to any mill trimming and squaring operations. This machine consists of roller conveyor beds which serve as a work support in the loading, cutting and unloading positions. Longitudinal tracks extend down both sides of this bed, and on a rolling bridge riding on these tracks are mounted two floating blowpipe units. The plate to be cut is motor driven into the cutting position and pneumatically pushed against stops. The two long edges of the plate are then beveled simultaneously, after which a third blowpipe unit operating from the transverse track is used to square off or bevel the two ends of the plate. The trimmed and beveled plate is then driven to the unloading position on the lower bed. The resulting plate edges are found to butt up accurately for welding with tolerances that are comparable to those obtained in the past with special edge-planing machines. Such edging equipment, employing oxy-acetylene blowpipes can be used to achieve high rates of production.

To meet the requirements of the various welding procedures and joint types, it is frequently found necessary to do combination cutting, that is, to prepare the plate edge by simultaneous cutting with two or three blowpipes mounted on a single blowpipe-riding device. Because of the floating feature of this device and the accurate control of the distance between cutting nozzles and plate it is possible to make long special edging cuts with a constant profile on large plates even if these should be buckled appreciably from the flat position.

Armor Plate Cutting and Treating

Much pressure has been exerted to bring about an increase in the production, shaping and treating of armor plate. Melting-furnace capacities have been over-

taxed and new melting equipment is being installed as rapidly as possible. The same is true of shaping and heat-treating equipment. At one time the application of localized heat in any form to armor plate of any description was definitely outlawed. The pressure of the present armament program, however, has been such as to open the door for certain of the oxy-acetylene processes with the result that experimental work and trial

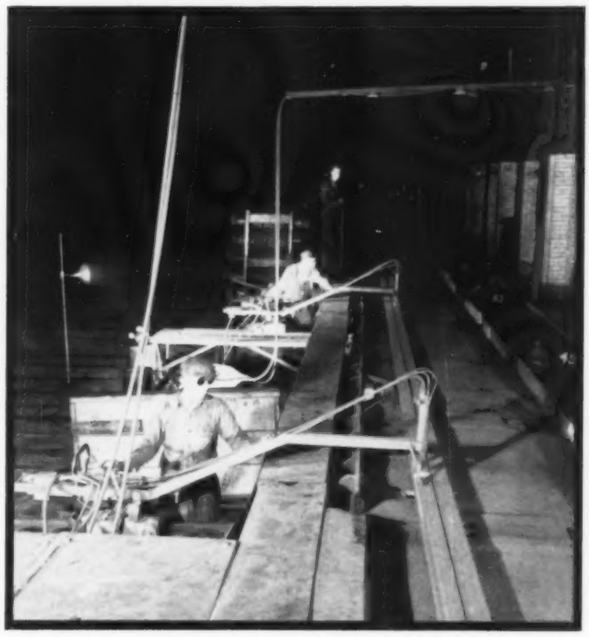


Figure 5 — Balanced extension blowpipe-supporting arms, pivoted on straight-line cutting machines, are used for hot billet cutting.

applications have now been converted in many instances to accepted practices. For example, the oxy-acetylene cutting of armor plate is now accepted for most specifications and thicknesses, and every day tons of plate are being trimmed to close tolerances. This reduction of machining requirements has done much to expedite the production of finished plates of many types.

The procedures employed in the flame-cutting of armor plate are essentially similar to those commonly used for the plain carbon steels, the general difference being that the cutting speeds are reduced slightly. As is true with all of the hardenable steels, the armor-plate compositions respond to the flame-cutting process in such a way as to leave the cut surfaces in a hardened and unmachinable condition. This effect arises from the fact that the heat of the cutting reaction and the preheating flames is sufficient to heat a thin layer of metal adjacent to the cut surface to a temperature above that required for hardening, with a subsequent cooling of this heated layer at a sufficiently high rate to produce appreciable hardening. Sometimes the cooling rate may be quite severe because of the rapid flow of heat away from the surface layer into the mass of cold metal shortly beyond. It should be noted, therefore, that whereas it is entirely feasible to produce accurate and economical flame-cuts of high quality in armor plate, there is an unfavorable metallurgical reaction which must be given consideration.

Several methods of correcting the disturbance created by the flame-cutting action have been employed. The oldest of these, a procedure well known to many who have had occasion to cut high-carbon and alloy steels, is preheating. This technique involves the heating of the plate to be cut to some elevated temperature, thereby lowering the temperature gradient between the cut surface and the steel mass. When the temperature gradient is thus sufficiently lowered, cooling will be reduced to a rate which does not produce objectionable hardness or unmachinable metal. This procedure involves considerable handling and heating equipment and because of these requirements the flame-cutting process has been slow in making headway in the cutting of the hardenable steels.

Another method of eliminating the hardened zone created by flame-cutting, involves the reheating of the cut plate either as a part of a subsequent heat-treatment or as a special tempering treatment to remove the objectionable hardness of the cut surface. This procedure is employed today in the cutting of tank armor in which the plates are cut to size before the final heat-treatment prior to machining to finished dimensions.

A more popular treatment, which is both fast and economical and which is now in use, involves the reheating of the thin layer of affected metal adjacent to the cut surface by means of localized heat application. This procedure, known as "flame-softening," is merely a tempering or drawing heat-treatment which is restricted to the volume of metal which is hardened to an unacceptable degree. One accepted procedure provides for the passage of a row of closely spaced, efficient, high-velocity oxy-acetylene flames across the flame-cut surface at a rate of speed sufficient to heat the hardened zone to a tempering temperature of 1,000 to 1,200 F. The effect of this treatment is to reduce the hardness of the flame-cut edge materially, and thereby to restore the toughness and requisite machinability. In employing this procedure it has been found that handlingcosts are low, no additional furnace capacity is involved, and production is maintained at a high rate. A close-up view of an oxy-acetylene flame-softening head in operation of 6 in. armor plate is shown in Figure 8.

Two general types of armor plate are now regularly employed. These are referred to as face-hardened plate and homogeneous plate. In the first type of armor the combination of extreme toughness and shock resistance, with high surface hardness, is obtained by controlled variations in composition and heat-treatment. The plates in question are usually carburized to a depth of 20 to 30 per cent of the thickness to provide the carbon content necessary for extremely high hardness. Special heat-treatments are applied to these plates, but these compare in a general way in most instances with the heat-treatments normally followed in the treating of ordinary case-carburized parts.

With homogeneous armor plate no attempt is made to vary the composition of the plate from surface to surface, and a uniform heat-treatment is applied to

produce as much hardness as may be compatible with a high degree of toughness.

Some years ago, in the early development of the flame-hardening process, a few experiments were conducted to determine the advantages to be obtained by using the flame-hardening process to improve the ballistic resistance of homogeneous armor plate. These early tests indicated that there might be considerable advantage to be obtained by this method. As a result of these and other trials the subject has been reopened during the past two years and additional experimental work has been conducted. Pilot tests have shown conclusively that the ballistic resistance of homogeneous plate can be markedly increased through flame-hardening after pretreatment.

Whereas the process as applied strictly to armor plate has not yet been applied on a production basis, it is believed that there is considerable future for this process, and the writer is confident that, as a specified practice, the flame-hardening of armor for many applications, particularly tanks, is not far distant. It is probable that the duplex physical properties of the carburized plate may never be obtained by this method, but it is certain that the ballistic resistance of the homogeneous types will be materially improved. It s possible that a third or intermediate type of plate may be introduced through the oxy-acetylene flame-hardening process.

It should be understood that there are some limitations in the application of flame-hardening to armor plate. The two most important of these are the distortion of the plates and the depth of penetration of the hardened zone. It has been found that it is difficult to maintain flatness in flame-hardening plates under ¾ in. thick, although it is quite possible that further experimental work now under way may lead to the establishment of procedures which are not accompanied by excessive plate warpage.

With regard to the depth of case possible with the flame-hardening process, there are fairly definite limitations. It is possible to develop maximum surface hardness for limited depths only, and procedures employed to produce case thicknesses beyond this limiting depth will be accompanied by some sacrifice in surface hardness. In flame-hardening, the surface hardness obtained, is, to a large extent, dependent upon the flow of heat to the cold metal below the surface to produce a so-called self-quenching action. Obviously, in attempts to drive in a deep case there must be a decrease in the temperature gradient between surface metal and interior, which results in slower cooling and decreased hardening.

The flame-hardening process is not restricted to rolled or forged plate, but may be applied to cast armor as well. No specified applications are as yet adopted, but it is quite possible that with improvements in the design of armored units flame-hardened castings may be employed.

Another helpful application of the oxy-acetylene process has been developed in the descaling of armor plate, particularly that in the cast form. This process involves simply the fairly rapid passage of the high-

TABLE I

Production Data for Cutting Cold Round and Square Bars (3-Blowpipe Operation)

Bar size, in.	Preheating time, sec.	Cutting time, sec.	Handling time, sec.	Total time, sec.	Production rate, pieces per hr.	Probable production, pieces per hr.
			ROUND BARS			
3	5	15	12	32	336	280
4	7	20	15	42	255	220
6	9	38	20	67	159	135
8	12	63	30	105	102	85
10	15	98	45	158	66	55
			SQUARE BARS			
3	4	17	12	33	327	270
4	6	23	15	44	243	200
6	8	41	20	69	156	130
8	10	69	30	109	99	86
10	12	107	45	164	66	55

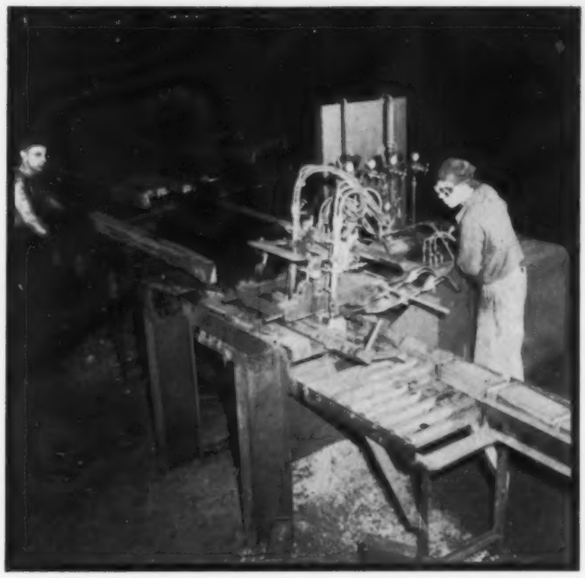


Figure 6 — A new-type multiple blowpipe billet cut-off machine can be equipped with as many as five blowpipes for high production.

temperature, high-velocity oxy-acetylene flames over the scaled surfaces to be cleaned. The effect of this treatment is to heat rapidly the adherent scale to the point where its expansion is such as to cause it to loosen and pop from the metal surface beneath, which remains cool. In some instances this method of descaling has been found to be particularly effective as an aid to subsequent machining. In some compositions, however, there exist certain types of tightly adhering scale which do not readily respond to this descaling action. Frequently, a combination of flame-descaling, and sand-blasting or bobbing, is found to be effective.

Surface-Conditioning

The acceptance of hand-scarfing throughout the steel industry has been quite general and it can be reported that both the number of users and the number of scarfing blowpipes have increased at even a higher rate that that of production capacity percentage. No radical changes in the basic process have been developed during the time of the emergency program. There has been continued improvement of oxy-acetylene scarfing equipment, however, with particular respect to the blowpipes which are now appreciably lighter, more durable, and more efficient than the earlier models. A number of comprehensive comparative hand-scarfing tests using acetylene in competition with other fuel gases have been conducted during recent months with the result that acetylene is more firmly established than ever before as the most economical fuel gas for this purpose.

The old bridge-type scarfing machine which has been used for surface removal on slabs and billets for many years, both in the United States and Great Britain, has been adapted to new uses. Machines of this type are now in use for surface-removal work on ingots and heavy armor-plate slabs. Special heads and additional water-cooling arrangements have been developed to meet the new applications, as much of the scarfing now done on these machines, which were primarily designed for cold-steel desurfacing, is now done on steel at temperatures ranging between 400 and 1,000 F. Additional machines of this type for the desurfacing of armor-plate slabs are under consideration for installation in the near future.

The greatest oxy-acetylene developments of the past few years have been in the field of mechanized hot-surface removal. Several new types of steel-conditioning machines have been developed and installed where they are in steady operation, and a number of additional new types are in manufacture for installation before the close of the year 1941. To date we have constructed and installed 25 surface-removal machines. Of these 25 machines, all are in steady production operation with the exception of those which have been replaced by more modern machines of improved types or because

Figure 7 — This is a plate-squaring and -edging machine of popular design.

of changes in mill operating conditions. A number of additional machines are in various stages of construction for installation as a definite part of the defense program.

The essentials of the operation of the desurfacing machines have been clearly described in an earlier issue of this publication by E. A. Doyle, (Hot Scarfing of Billets, Blooms and Slabs, *Iron and Steel Engineer*, May, 1941) and it is not proposed to repeat this detailed information here. It is admitted that, in the course of developing a sizeable number of machines of different types, much has been learned. Improvements in design resulting in better operation have been incorporated in the newer models and applied to existing installations. The basic advantages of mechanized hot-surface re-

moval remain unchanged and are of greater importance under the present high production demands than ever before. These, briefly, include savings in space, time, reheating, crane service and handling, (all of which combine ultimately to reflect themselves in increased production), improved product, higher yield, and overall savings.

Certain trends in the demand for desurfacing machines during the past year or two are of interest. The most important of these is the requirement for quick size change by either manual or remote control to meet rolling schedules without mill delays. Much development effort has been directed toward this need, with constant improvement of this feature of the adjustable machines as a result. It has also been found to be highly desirable, where space permits, to mount the machines on transfer carriages which are used to run the machines out of the line, replacing them with idler rolls. This has proved to be a means of simplifying and speeding up maintenance, overhauling and adjustment.

Standard type of machines can be rolled in and out of the line on a transfer carriage. Standard machines of this type are adjustable to handle any square section on the flat between 4 in. by 4 in. and 10 in. by 10 inch. In addition, slabs ranging in size from 2 in. by 4 in. to 10 in. by 10 in. may be scarfed on all four sides simultaneously, and the edges only of slabs between the limits of 2 in. by 4 in. and 10 in. by 20 in. may also be scarfed. An intermediate-sized machine has been designed to scarf four sides simultaneously of squares from 5 in. by 5 in. to 14 in. by 14 in. and slabs from 2 in. by 8 in. to 14 in. by 32 in. It will also scarf the edges only of slabs from 2 in. by 8 in. to 14 in. by 42 in. The largest machine available at present has been designed to scarf four sides of squares from 6 in. by 6 in. to 18 in. by 18 in., and four sides of slabs from 2½ in. by 20 in. to 18 in. by 52 inches. This same machine will scarf the edges only of slabs ranging from 2½ in. by 20 in. to 18 in. by 66 inches. The above capacities are cited primarily to give some idea of the limitations of the available sizes of desurfacing machines. It should be understood that as the capacity of the machine is increased, so are the overall dimensions, clearance requirements and gas demands.

Concurrently with the development of the larger desurfacing machines has been the progress in the necessary developments in gas-supply equipment and apparatus. The largest types of machines when equipped to scarf slabs of the maximum size on all four sides may require oxygen at instantaneous rates in excess of 300,000 cu ft per hr, and acetylene at an instantaneous rate in excess of 8,000 cu ft per hr. The average hourly consumptions for these gases will be consideralby less than the above instantaneous demand rates, depending upon the actual sizes being scarfed, and the rolling schedules.

From the brief survey of the more important oxy-acetylene processes described above, it can be concluded that the part played by these processes in the national defense program is something far beyond the matter of maintenance and repair as was true in the average mill some years ago. These processes now play an active and essential part in most phases of steel production from the scrap yard and blast furnace to the finished product, in the fabrication and treating of the steel in practically every industry, and, finally, in the demolition and scrapping of the steel after it has served its purpose.

Figure 8 — This oxyacetylene flame-softening equipment is flame-cutting 6 in. armor plate.

DISCUSSION

MARTIN J. CONWAY, Special Engineer, Lukens Steel Company, Coatesville, Pennsylvania

J. H. ZIMMERMAN, Development Manager, Linde Air Products Company, New York, New York

MARTIN J. CONWAY: Again I feel that quite a lot of credit is due to the author of this paper for its preparation, and particularly the part dealing with flame-machining. As a member of an organization doing a substantial amount of this type of work, I can say "Hear, hear" to almost all that the author has said. I will of course confine my remarks to flame-machining.

I would like to ask Mr. Zimmerman two or three questions. What experience has he had in the flame-hardening of low-carbon steel containing 1 per cent to 1¼ per cent manganese, and what carbon composition would he, from his experience, recommend as a a peak?

One other question on the flame-beveling of plate — Has he had much experience in the making of a U-or

J-bevel, such as used in the fabrication of pressure vessels, and if so, was this done by the continuous machine method, and what tolerances did he work to?

What tolerances can he work to on, say, 1 in. or 1½ in. plates?

J. H. ZIMMERMAN: As for the first question about the carbon content of steels containing 1¼ per cent manganese, I am not prepared to say specifically what compositions might be flame-hardened satisfactorily. I would guess offhand that you would want from 30 carbon up to the point where you began to get cracking. You probably would get higher hardnesses as your carbon increased, until it became impossible to harden with a water quench, at which time you could probably change over to an air or mist quench, and eventually reach the point where the self-quenching would be sufficient. Where the dividing line would come between the various methods of quenching and the results, I cannot say definitely.

In regard to the preparation of the U-type edge for Class 1 welding of pressure vessels, we have never been able to produce accurately the precise angles and radii that are prescribed in the A.S.M.E. code. On the other hand, a great deal of U-groove preparation is being done on the theory that the U-groove we do produce is sufficiently accurate to make the welding preparation, although it may not conform in dimension.

There are a number of methods of producing these edges. Some of these have been in production for some time. Probably the simplest method is to prepare, first, a bevel, and then follow that bevel with a gouging operation. This removes metal from the beveled edge to leave a small nose, and clears away the metal to prevent short-circuiting across the narrow bottom of the V. Of course the purpose is to open up the bottom of the joint, the rest being a matter of keeping it as small as possible, in order to cut down the amount of metal that has to be deposited.

The third question was about tolerances. There are so many circumstances that enter into the matter of tolerances, even with the single thickness you mentioned of 1 in. plate, that I believe the answer should be that the tolerances that can be met are largely dependent on the mechanical equipment used to guide the blowpipe.

The cut itself, once cutting conditions have been established, will, of course, operate as long as the nozzle is clear, to give constant kerf width. Therefore, once the adjustment has been made for the edge, everything else depends on whatever pushes the blowpipe.

There are a great many installations in which accurate cuts are being made for edges that are up to 40 ft in length. Ship plates, for example, are butted together after a simultaneous cutting and beveling, with an opening between plates that does not exceed 1/16 in. in the 40 ft, and usually is considerably less. Frequently it is only a matter of a light grind on one spot on the plate edge to give almost a tight fit-up. Parallel cutting eliminates the tendency toward crawling, and introduces symmetry to the problem, thus eliminating some of the heat effects that occur if one edge is cut at a time.

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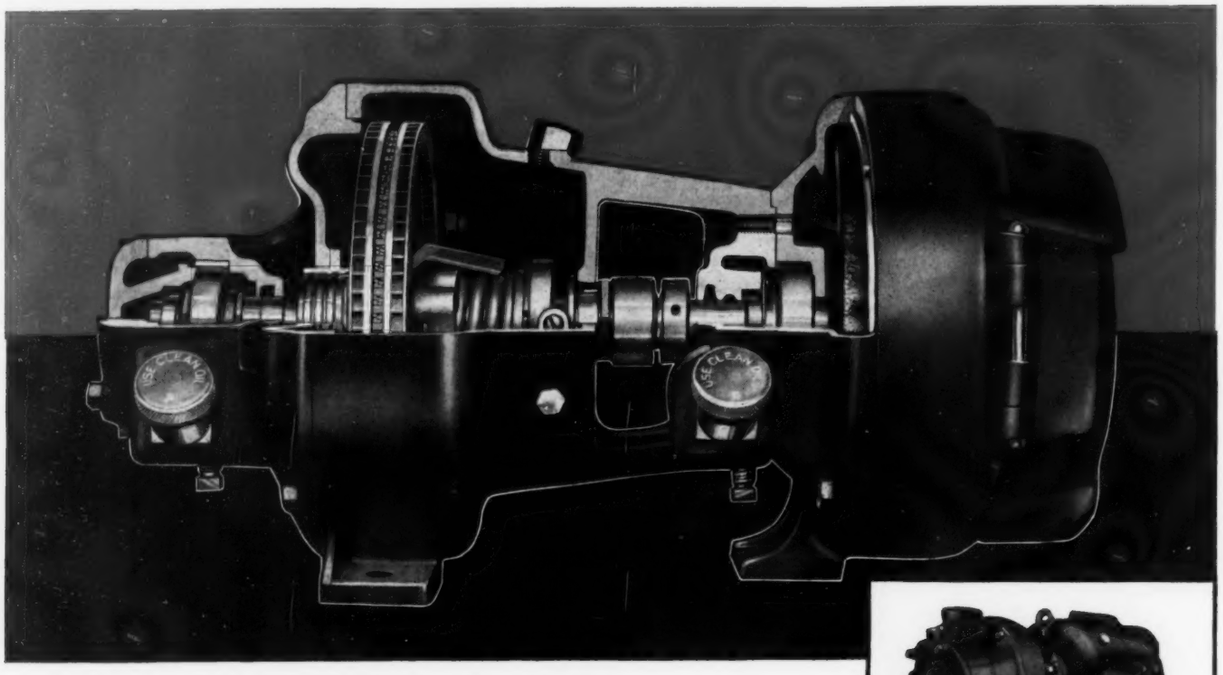

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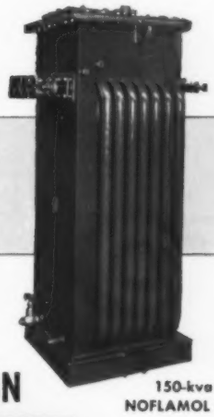
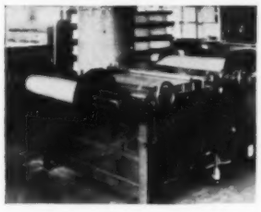


150-kva Wagner NOFLAMOL Transformer

1½-kva Wagner Air-Cooled Transformer

75-kva Wagner HEX Transformer

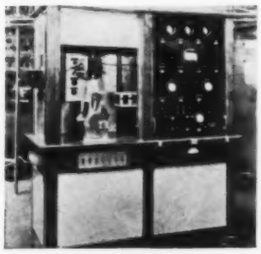
ACCURATE TESTING ASSURES SATISFACTION



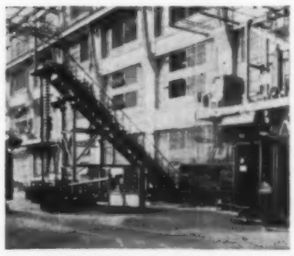
Above, Insulation-Testing Machine. Used to make sure that insulating materials have characteristics that meet Wagner's rigid specifications.

Right, "Epstein test" of Silicon Steel. Every heat in each shipment of core lamination is rigidly tested by Wagner for specified electrical and physical properties.

Below, Surge Generator. Used primarily for impulse-testing of transformers and special testing of various types of insulations.



Left, Cathode-Ray Oscillograph. Used with surge generator to obtain records of the surges which are applied when impulse-testing transformers.



For complete descriptive literature on the design and construction of Wagner Transformers write for bulletins TU-180 (Distribution) and TU-181 (Power). They will be sent FREE upon request.

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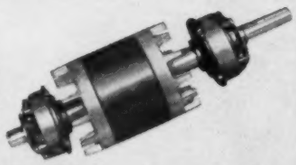
Steel plant operators know that goggles prevent eye injuries and save man-hours. Belts and gears are housed for protection of workers, but in many cases motors of open frame construction are still being used in surroundings where dust, dirt, abrasive materials, steel chips, filings, and acid fumes are prevalent. As a result, motor windings become clogged, bearing surfaces wear excessively – motor life is shortened, causing valuable machine-hours to be lost.

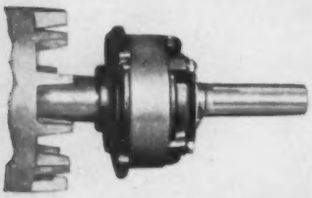
Regardless of the kind of auxiliary equipment they are driving, Wagner CP motors stay on the job, requiring no maintenance other than periodic inspection and oiling, despite the destructive elements in the surrounding atmosphere. Keep your production at top peak – eliminate shutdowns with Wagner CP motors.

FEATURES OF WAGNER *CP* MOTORS

WINDINGS—The windings are insulated with the best materials obtainable, used in generous amounts. The windings are pre-formed to exactly fit the stator slots without crowding. They are effectively insulated from the stator punchings by cuffed slot-cells made of tough fibrous material. The exposed parts of the windings are completely taped well into the slots, and the assembled stator windings are treated with high-grade insulating varnish, giving the coils a glossy surface for easy cleaning.

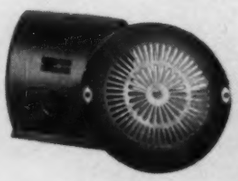
ROTOR—The squirrel-cage is of aluminum, cast under heavy pressure to completely fill the closed rotor slots and the moulds which form the end-rings. The rotor bars and end-rings make complete and intimate contact with the core iron, facilitating heat transfer and absolutely eliminating squirrel-cage vibration.

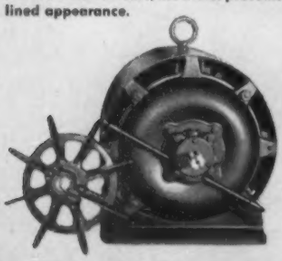




BEARINGS—Full cartridge construction for the ball bearings makes it impossible for dust or dirt to reach them even when the rotor is removed from the motor. The cartridges are heat treated, and then machined to dimensions which are held to tolerances less than a thousandth of an inch, to match the accurate dimensions of the bearings. Wagner CP motors are quickly lubricated without interrupting their operation.

STATOR AND FAN SHIELDS—The stator shield is formed from steel plate and is rigidly bolted to the motor frame. The fan shield is also formed from steel plate with the grating as an integral part of the shield. No wire mesh is used because of its lack of rigidity and consequent inability to protect the ventilating fan. Because of close tolerances and snug fit between stator and fan shields, the motor presents a streamlined appearance.

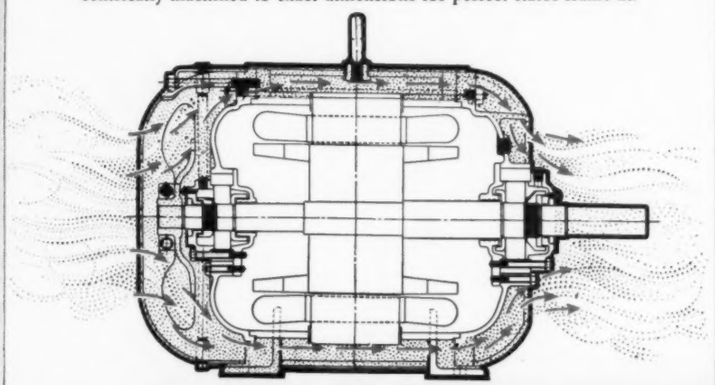




VENTILATION—The air ducts of Wagner CP motors are extra large and do not become clogged by dust or dirt. The ventilating fan is of aluminum, does not produce sparks when accidentally hit by metal, and moves a large volume of air at high velocity.

TOTALLY-ENCLOSED FAN-COOLED

Wagner type CP totally-enclosed fan-cooled motors have two frames: an outer frame which guides a strong cooling draft over the motor, and an inner frame which protects the vital parts of the motor against the entrance of destructive agents. Ball bearings are used throughout. Cartridge completely seals bearings against dust and dirt when the rotor is assembled in or removed from the motor. Endplates are concentrically machined to exact dimensions for perfect stator-frame fit.



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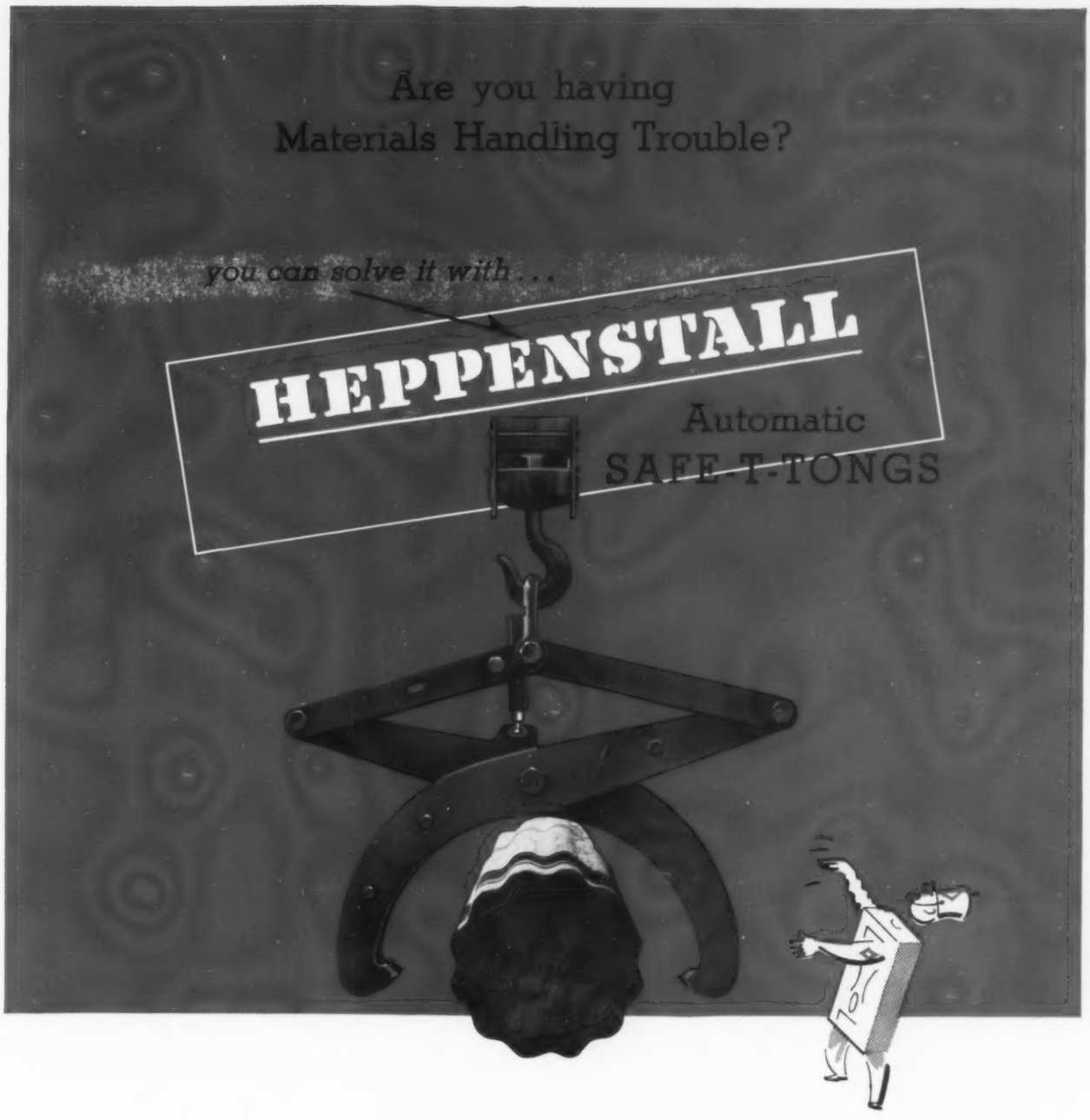

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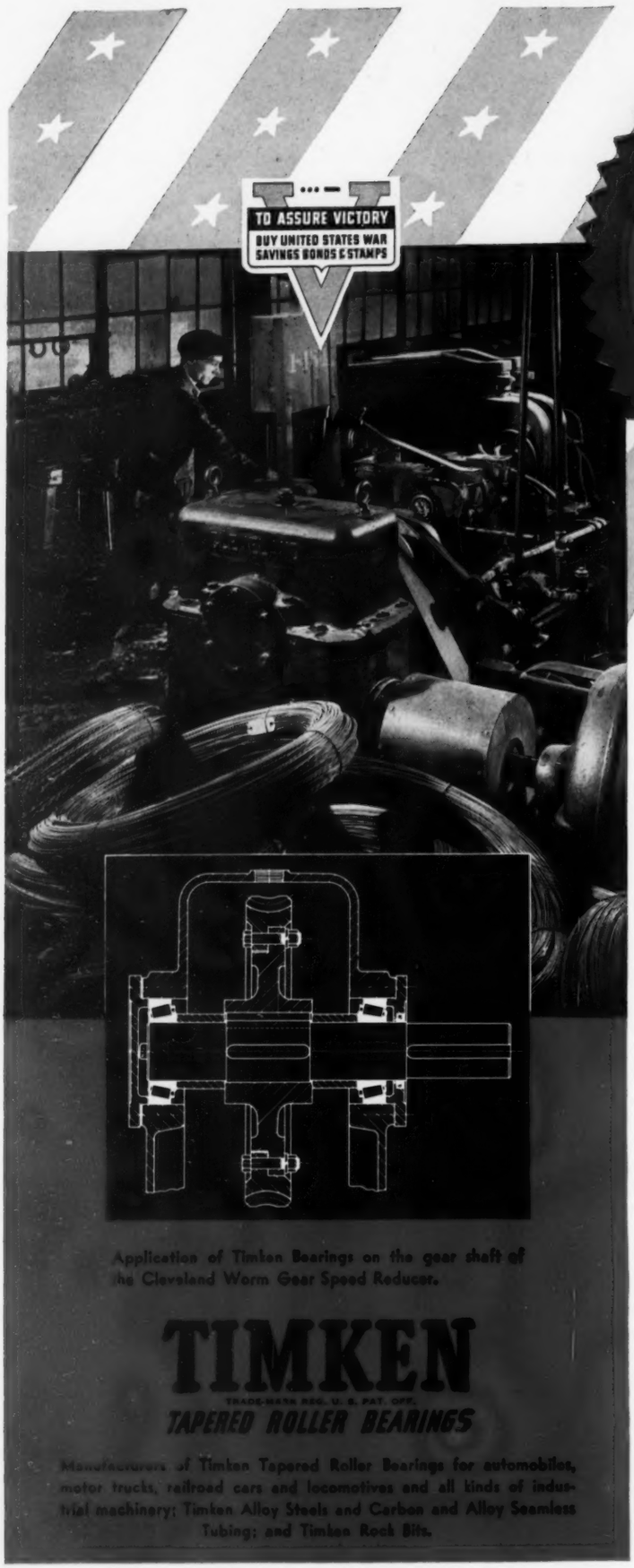

Application of Timken Bearings on the gear shaft of the Cleveland Worm Gear Speed Reducer.

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The Cleveland Worm Gear Speed Reducer, Type 500 AT, shown in the photograph is driving a cold rolling mill producing cotter key wire. It was installed in 1930 and has been on the job ever since. The gear shaft is supported on Timken Tapered Roller Bearings and no bearing has had to be replaced since the reducer went into operation. That's *service!*

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What EVERY INDUSTRIAL ENGINEER SHOULD KNOW ABOUT HYDRAULIC ACTUATION FOR CRANE BRIDGE BRAKES

Higher crane speeds . . . the use of roller bearings which increase the danger of the crane going through runway bumpers when power fails . . . the necessity of accurate load-spotting and positive parking —these are a few of the reasons why every industrial engineer should know about hydraulic actuation for crane bridge brakes. Today, with production at an all-time high, the application of powerful and positive foot-operated hydraulic brakes to crane bridge drives is a practical necessity.

The following application details must be considered when equipping overhead traveling cranes, coke oven machinery, transfer cars, etc., with bridge brakes:

1. Minimum possible stopping distance.
2. Coefficient of friction between wheels and rail.
3. Load per wheel.
4. Number of driven wheels.
5. Diameter of driven wheels.
6. Gear ratio between wheels and shaft on which brake is mounted.

Minimum Stopping Distances

The coefficient of friction between the braked wheels and the rails determines the amount of useful braking force that can be applied without slipping or sliding the wheels. Since it is not practical to install brakes on the track wheels, they are usually applied to the bridge-drive motorshaft which means that the braking force can only be applied to the driven wheels. Therefore, the minimum stopping distance of a crane moving at a given speed will depend upon the coefficient of friction between the wheels and the rails and the percentage of wheels that are braked.

Useful Braking Torque

The maximum amount of useful braking torque in foot pounds that can be applied to the bridge motor shaft is determined as follows, where:

K = coefficient of friction.

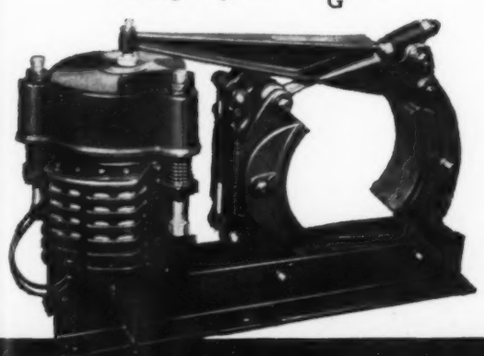
W = load on each driven wheel.

R = radius of driven wheel.

N = number of driven wheels.

G = gear ratio between wheel axle and motor shaft.

$$\text{Braking torque} = \frac{W \times K \times R \times N}{G}$$



Brake Sizes

Brake size has varied through wide limits on cranes of various designs equipped with mechanical brakes. Three factors of prime consideration in determining the brake size for a particular application are:

1. Brake must be large enough to provide sufficient torque and heat dissipation.
2. Brake must be designed so that pedal pressures stay within the physical limits of the operator.
3. If possible, brake output should occur simultaneously with brake application which means that the system should have a minimum of "slop" in the bearings, shaft deflections, linkage frictions, etc.

It has been found that these problems can be more easily and efficiently handled by adapting *hydraulic* brake systems to bridge drives. It is now possible to obtain very satisfactory performance from hydraulic brakes of smaller size provided they are efficiently designed and used with proper brake wheels.

Brakes for Inside and Outside Cranes

Two types of brakes were found necessary because of the need for a parking brake as well as a service brake. The Wagner type H brake is a hydraulically actuated bridge-brake used for normal service stops on inside overhead traveling cranes while the HM brake is designed for use on overhead traveling cranes, installed on outside runways, which require some means of locking them in position when not in service. The type HM brake is the same as type H insofar as it is hydraulically actuated when the crane is in operation but it has, in addition, a spring-applied magnetic-release parking-brake attachment.

Typical Hydraulic Crane Brake System

The principle of hydraulic actuation used in Wagner hydraulic bridge braking systems is exactly the same as that applied to passenger cars and commercial vehicles. A typical system consists of a hydraulic master cylinder in which the hydraulic pressure is originated, a hydraulic wheel cylinder of the telescopic type, and the necessary fluid lines and flexible hoses.

The hydraulic master cylinder is mounted in the cab in a convenient location for the operator.

Hydraulic pressure, built up in the master cylinder by means of foot pressure on the pedal, is transmitted through the hydraulic fluid line to the hydraulic wheel cylinder which is mounted between the brake arm and the brake lever.

Fluid displaced from the master cylinder operates the wheel cylinder which moves the end of the brake lever-arm upward with a force approximately three times as great as the foot pressure exerted, thereby bringing the brake shoes into contact with the brake wheel. The amount of braking torque varies directly with the foot pedal pressure.

When pressure on the foot pedal is released, the brake assembly is returned to its full-release position by a tension-type spring hooked between the brake arm and brake lever.

If two brakes are used on the same bridge, both can be operated simultaneously through the master cylinder the same as four-wheel hydraulic brakes on an automobile.

Type HM Brake

The type HM brake, mentioned above, has a shunt-wound solenoid, equipped with a protecting switch and discharge resistance. The solenoid has ample power to allow the use of powerful springs to set the brake for parking. When the electric power, used to operate the crane, is shut off or fails, the solenoid automatically releases the springs which set the brake.

Coke pushers, coal-charging cars, door machines, and transfer cars are ideal applications for the HM brake since it is desirable that such equipment be held in position on the track while discharging their principal functions. In such applications, the solenoid is connected across the motor line so that the brake can be released while the motor is running.

●

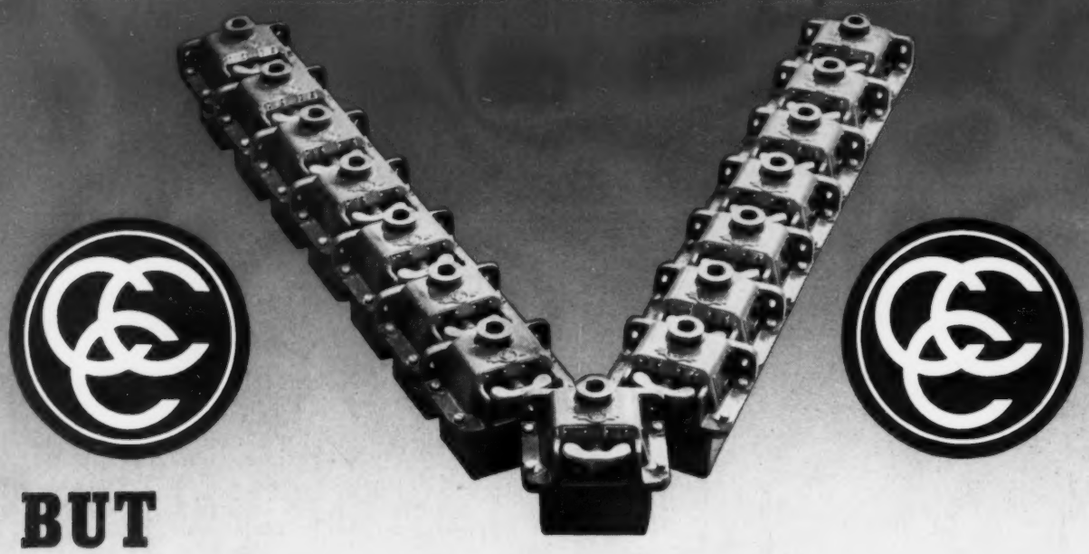
ASK FOR BULLETIN IU-20

For a complete description of Wagner Hydraulic Bridge Brakes—where to use them, how they operate, how they are made—write for Bulletin IU-20. Wagner Electric Corp., 6483 Plymouth Ave., St. Louis, Mo., U. S. A.

I42-1

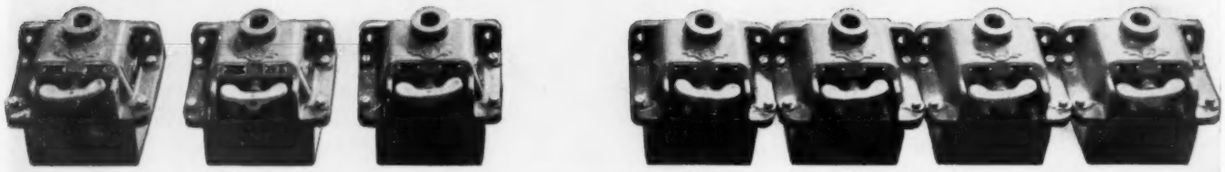
Wagner Electric Corporation

NOT "Somewhere West of Laramie" . . .



BUT

Somewhere Deep in the Heart of Industrial America



Maybe in an explosives plant—maybe where gas fumes lurk—maybe in dust laden atmospheres—but someplace where an explosion would wreck an industrial plant—these "3C" Bulletin 100, Type D Heavy Duty Push Buttons are "lined up" in a "V for Victory" Production Drive.

They're built to rigid underwriters' specifications for Class 1, Group D, Hazardous Locations, either with or without oil. The addition of oil eliminates the action of corrosive gas, and smothers any arc generated at the contacts.

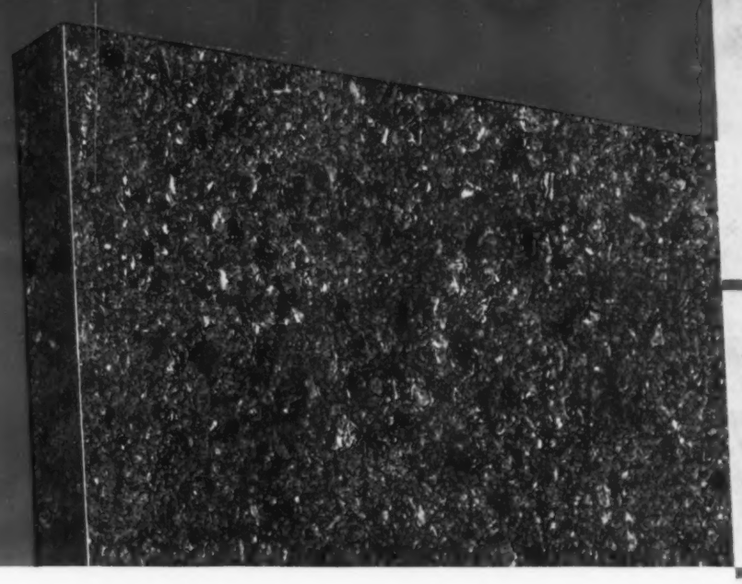
Conveniently located operating lever can be manipulated with a gloved hand—but ample guards on each side prevent accidental operation—and the Station can be locked in either "OFF" or "STOP" position.

The same sturdy mechanism found in all "3C" Type D Push Buttons is used in these Explosion Proof Buttons—Silver to Silver Button Type Double Break Contacts—Bakelite Insulation Parts—plenty of clearance and wiring space—all parts replaceable with screw-driver—and other features

OFFICES IN PRINCIPAL CITIES

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, OHIO



Reduce CORROSION LOSSES DEPRECIATION MAINTENANCE EXPENSE

in Pickling, Plating and Other Processes Involving Electrolytic Action

Use NATIONAL and KARBATE TRADE-MARK TRADE-MARK CARBON and GRAPHITE PRODUCTS

● Carbon and graphite products are adapted to a wide variety of applications where difficulties are encountered with other materials as a result of thermal shock or reaction with process materials. They are resistant to the action of most acids, alkalies and solvents, possess good mechanical strength and exceptional resistance to thermal shock. Graphite and graphite base "Karbate" products have higher thermal conductivity than most metals. "Karbate" materials are impervious to seepage of liquids and gases. Porous carbon and graphite products, of high permeability, are also available.

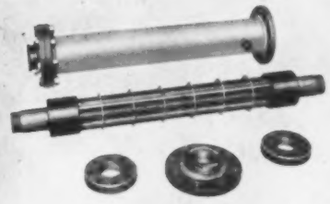
Carbon and graphite products are manufactured in a variety of forms and, being easily machined, can be fabricated to meet almost any structural requirement.

Thousands of dollars are being saved in the metal and process industries by the use of carbon and graphite elements in the construction of equipment subject to corrosive action or severe thermal shock. Products shown at right illustrate the versatility of these materials.

WRITE NEAREST DISTRICT OFFICE FOR INFORMATION ON THESE PRODUCTS

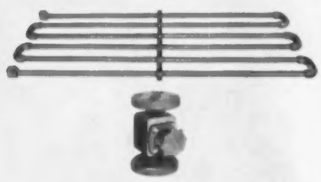
POROUS CARBON AND GRAPHITE

For agitators, steam spargers, gas diffusers and filters. Several grades, differing in degree of permeability, are available. Resistant to both corrosion and thermal shock. Can be fabricated in practically any required form.



HEAT EXCHANGERS

Constructed from "Karbate" tubes and fittings. Bayonet, immersion, cascade, concentric tube, tube bundle and gas flame types. Shell and tube types with either metal or "Karbate" shell. Many installations in successful use for heating, cooling, condensation or absorption of corrosive materials.

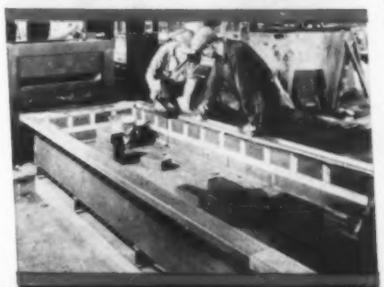


PIPE, VALVES, PUMPS AND FITTINGS

For the construction of conveying or circulating systems carrying or in contact with corrosive materials, carbon, graphite and "Karbate" pipe and accessories eliminate corrosion difficulties. Permit construction of complete circulating systems in which solution has no contact with metal.

FABRICATED CONTAINERS

Tanks, vats and other containers for corrosive materials can be constructed from carbon, graphite and "Karbate" parts, providing economical and permanent construction.

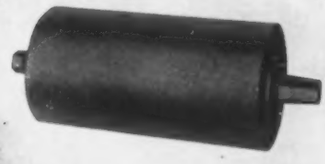


TANK LININGS

Carbon and graphite brick and other special shapes provide a durable lining for pickling tanks and other containers where resistance to corrosion or thermal shock is essential.

GRAPHITE ELECTRODES

In the electrolytic pickling of strip steel, fabricated graphite electrodes provide increased life, ease of installation and freedom from reaction with pickling solution. All parts made of graphite.

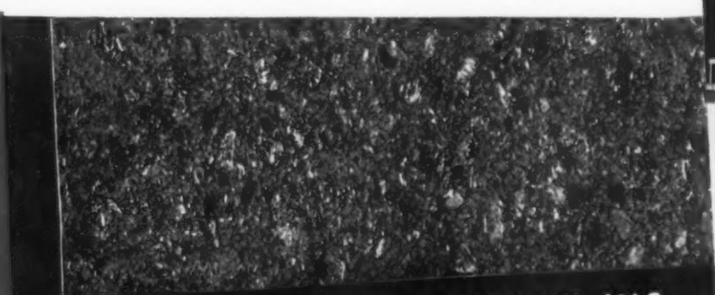


CARBON ROLLS

Carbon not attacked by most plating or pickling solutions. Have demonstrated long life and improved performance.

GRAPHITE BEARINGS

Self lubricating. Can be machined to close tolerance. Bearings, bushings and rings of graphite or carbon-graphite composition are used where oilless or corrosion resistant materials are needed.



NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC
CARBON SALES DIVISION, CLEVELAND, OHIO
General Offices: 30 East 42nd St., New York, N. Y.
Branch Sales Offices: New York · Pittsburgh · Chicago · St. Louis · San Francisco

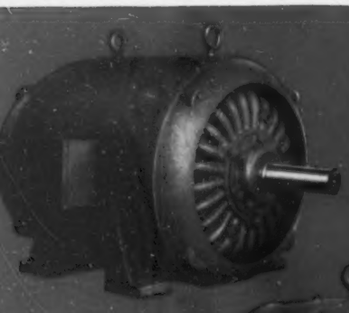
These 2 Words MAKE MOTOR-DRIVE More Than POWER!

Motor-drive provides within itself a means of:

Speed Control	Reversing
Braking	Remote Control
Tandem Operation	Controlled Acceleration
Tension Control	Safety

Slow Speeds for inching, threading, inspection

Applying them to boost production and improve quality is APPLICATION ENGINEERING. That's our business.



Enclosed, Fan-cooled A-c. Reliance Motor.

Crane-type Enclosed D-c. Reliance Motor.

● PRODUCTION jobs, not merely power jobs, are awaiting these RELIANCE MOTORS. They will do *many things* which will aid in performing some part of a production process faster, better, or more safely. Users of these motors will have more for their money because they started their production plans with the question, *"What can we make the motor do besides supply power?"* Get the complete answer to this question when your plans are in their early stages. Invite a Reliance man to sit in . . . He may not have all the answers, but he will have enough of them to be a big help in finding the right one.

RELIANCE ELECTRIC & ENGINEERING COMPANY
1088 Ivanhoe Road • Cleveland, Ohio

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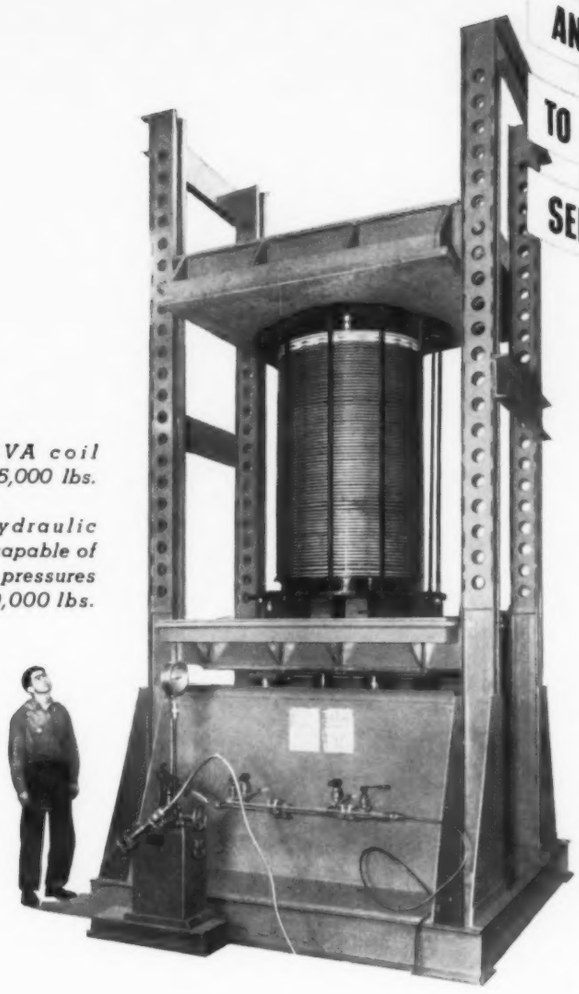
PORTLAND, ORE. • ST. LOUIS • SAN FRANCISCO • SYRACUSE, N.Y. • and other Principal Cities

RELIANCE A-C D-C MOTORS

ANOTHER *Pennsylvania* INNOVATION
TO INSURE UNFAILING TRANSFORMER
SERVICE FOR WAR INDUSTRIES . . .



5000 KVA coil under 125,000 lbs. pressure.
This Hydraulic press is capable of exerting pressures up to 600,000 lbs.

The fundamental principles of building transformers to withstand short circuits are as follows:

1. The coils and all insulation must be dried sufficiently to make sure that no shrinkage will take place when the transformer is in operation or is under a short circuit.
2. The dry coils must be pre-compressed to such an extent that no further compression can take place under the most severe short circuit. This definitely precludes any possibility of the coil stack moving or distorting under short circuit.
3. After drying and pre-compressing, the coils must be treated in such a manner that they are self-supporting and will maintain their pre-compressed and pre-shrunk shape when mounted on the core.
4. The final step is to provide sufficiently strong supports at the top and bottom of the group of coils to keep the coils in their pre-compressed shape.

Every Pennsylvania Transformer of the Helical and Pancake type is constructed on these principles.

A Sure Way of Building Transformers

THE ability of the coil to maintain its shape under the prescribed pressure is your guarantee that the transformer will withstand short circuits.

TO WITHSTAND SHORT CIRCUITS

Pennsylvania TRANSFORMERS

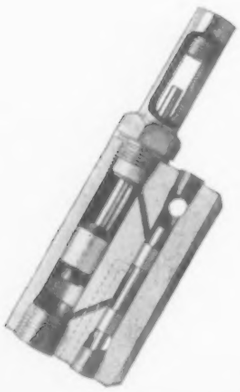
Pennsylvania TRANSFORMER COMPANY 808 RIDGE AVENUE • N. S., PITTSBURGH, PA.

Farval Pioneered Centralized Lubrication *sixteen years ago!*

1926-1942

Only the Farval Valve has all these vital features:–

- It contains no springs
- Has but two moving parts
- Contains no check valves
- Is individually adjustable
- Contains no small ports
- Will distribute either oil or grease
- Measures by piston displacement
- With a telltale indicator at every bearing



★ No other lubricating system can give you all these features. No modern Centralized System is complete without all of them. Why compromise the lubrication of your machines? Install Farval!

The Farval Corporation, 3278 E. 80th St., Cleveland, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Manufacturers of Automotive and Industrial Worm Gearing

In Canada: PEACOCK BROTHERS LIMITED

There are more Farval Systems installed on Steel Mill Equipment than all other makes combined

FARVAL

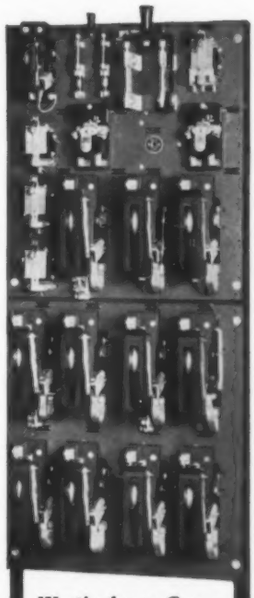
CENTRALIZED SYSTEMS OF LUBRICATION

High-speed light-hook lowering speeds up crane operation

Westinghouse D-C crane control speeds up operation by giving *faster* light-hook lowering speed . . . *without* excessive speeds when lowering heavy loads . . . *without* complications and hazards of load relays.

Westinghouse crane control gives smoother braking action by means of graduated dynamic braking which accomplishes the greater part of deceleration before the magnetic brake sets. This reduces wear on brake lining and wheel and imposes less stress on the crane.

Inching control is made more precise—load handling is made easier, quicker, more accurate. Write today for bulletin DD-9600 containing full details. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.



Westinghouse Crane Hoist Controller, Class 9635, with new 200 SM contactors.

J-21150

Westinghouse D. C. CRANE CONTROLLERS

WESTINGHOUSE ELECTRIC

Meet the Equipment Manufacturer

The Clark Controller Company

Herewith is presented the third in a series of articles outlining the history and development of the many companies servicing the iron and steel industry. It is felt the progress of the equipment manufacturer has been so closely allied with the upward march of the steel industry that our readers would be interested in the many developments sponsored by the manufacturer which were so helpful to the industry. In later issues this series will be continued.

▲ Undaunted by the headshakings of many wiseacres, a small group of stout-hearted engineers and business men, in August 1925, incorporated the Clark Controller Company, Cleveland, Ohio, a venture into the allegedly "saturated" field of electrical control equipment. The nucleus of the company, however, comprised men of 10 to 25 years experience in industrial control, and this experience, coupled with the desire to serve and the wise guidance of its executives, carried the company over the obstacles incident to its early history.

It was natural for the new organization to start along the already familiar line of heavy duty industrial control. The first item built for the market was the improved face-plate type manual controller, known for many years as the Dinkey controller. This item carried many innovations, including a structural steel welded frame, edge-wound non-corrosive resistors, and anti-friction bearings. The first shipment of the improved face-plate controller was made in January 1926.

Coincident with the production of these controllers, a new idea in magnetic brakes was developed, and soon this item, which gained rapid favor with its new, successful features, was in production, the first brake being shipped in March 1926.

From this modest start with manual controllers and magnetic brakes, other items were added to the "3C" line. Serious attention was given to the development of a line of magnetic contactors for heavy duty automatic magnetic control panels, resulting in the launching of a new idea in automatic time-limit acceleration. The now well-known Vari-Time contactor was (and still is) the basic feature around which practically all "3C" mill duty direct current automatic control panels were designed. Undoubtedly a basic contribution to the industrial control field, this idea resulted in great simplification of auxiliary control circuit wiring, and in the reduction of the number of auxiliary relays formerly considered necessary.

In 1930, the Sundh Electric Company was acquired, and its plant and offices were moved to Cleveland. This brought an established line of across-

PRIMUS P. C. CLARK — president since the company's inception — born in Indiana — graduated from Purdue — long experience in electrical control manufacturing before founding his own company — a rare personality, with keen insight and a host of friends.

W. H. "PETE" WILLIAMS — vice-president in charge of sales and another founder of the company — graduate of Drexel Institute — broad electrical experience — electrical control sales — manufacturer's agent prior to present association.

L. A. WATSON — vice-president and chief engineer — graduated from Syracuse University — several years in general electrical manufacturing — twelve years as engineer in electrical controls — one of the founders of Clark Controller Company.

J. J. "ANDY" MELLON — assistant sales manager — graduated from Rensselaer Polytechnic Institute — worked in electric utility field and in steel mill division of large electrical manufacturer — instructor in technical night school — joined Clark in 1929.

the-line starters, pressure regulators, float switches, etc., to round out the "3C" line.

From this point the company developed rapidly, and, surviving the depression years, continued to create new items and to improve old lines, stimulating competition so that industry in general has benefited by having several available sources of modern, simplified control.

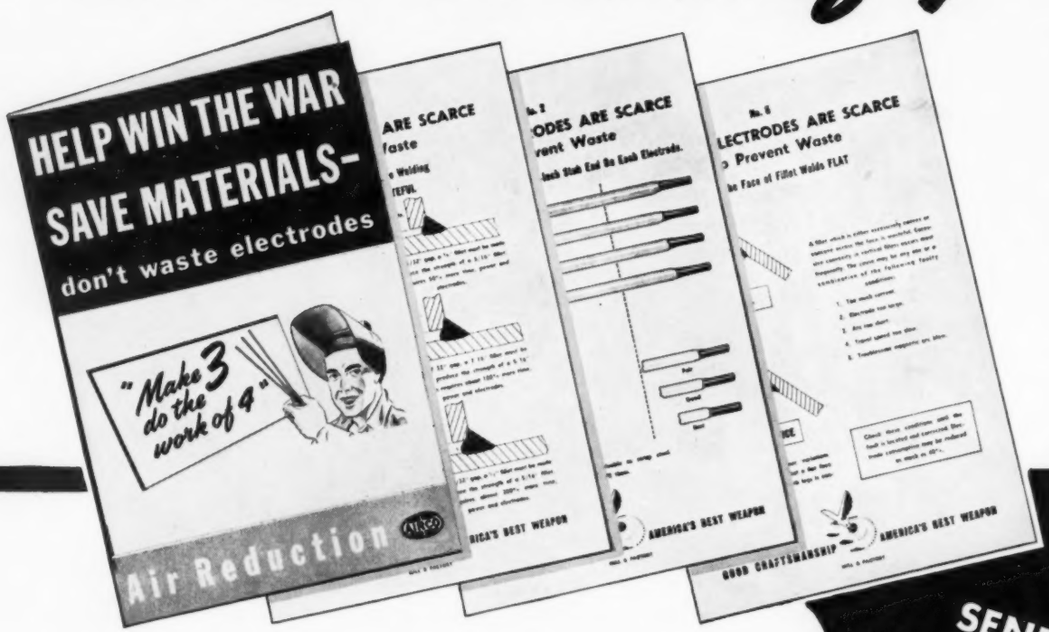
The development of new control units, and industry's splend'd acceptance of these devices, have naturally caused a parallel expansion in plant facilities. In 1929 the first major addition to the original plant was built, and other additions followed in 1930, 1932, 1936, 1939, 1940 and 1941. The buildings, located on East 152nd Street in Cleveland, now cover about seven times the area of the original plant, and the company owns an eight acre tract nearby, to be used for future expansion.

With one exception, the various departmental heads are the same as established at the inception of the company almost seventeen years ago. Many of the original employes are still in the organization, and it is to the loyalty and cooperation of its personnel that the company attributes its position in the industry.

On June 10, the Navy "E" award was made to Clark Controller Company. Rear Admiral William C. Watts, shown below with Mr. Clark, made the presentation. To the left is shown Captain H. A. Spanagel presenting the lapel insignia to Mrs. Charles Verhelst and Mr. Emil Hoffman, employe's representatives.

NEW SHOP BULLETINS

tell how 3 Electrodes can do the work of 4



Help your welding operators get the most out of every available electrode by eliminating all possible waste — that's the job that this new folder of shop bulletins will help accomplish. The folder contains a series of six posters, each stressing a waste eliminating "do" or "don't". *Clip the coupon today—and be sure to indicate how many copies you can profitably use.*

SEND FOR YOUR COPIES *Today!*

AIR REDUCTION

AIRCO

60 EAST 42nd STREET, NEW YORK, N. Y.

In Texas: Magnolia-Airco Gas Products Co.

AIR REDUCTION SALES CO., 60 East 42nd Street, New York, N. Y.

Please send my free copies of your electrode waste bulletins "Help Win the War—Save Materials—don't waste electrodes."

Check number of copies desired.

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IDLE CYLINDERS ARE PRODUCTION SLACKERS: KEEP 'EM ROLLING FOR VICTORY!

It's up to US...

First!

Strategically, the time might be right

THE enemies' over-extensions... the readiness of the "underground" and the guerrillas... the eagerness of our fighters — all the circumstances might be right... BUT —

The success of *this* year's offensive is up to *us*, all of us who read this magazine, who have the responsibility of *getting out the goods*.

Only when we have done our job can we hope to win.

Yale Pump Division Meets 1943 Schedules in 1942

Here at Yale & Towne's Pump Division, every man in our engineering department and in our shops knows that output considered good enough last December 6 is not good enough today.

We take pride in the fact that the war industries and our armed forces are receiving Yale Pumps at a rate we *had hoped* to reach in 1943! And standards of *quality* have been maintained throughout.

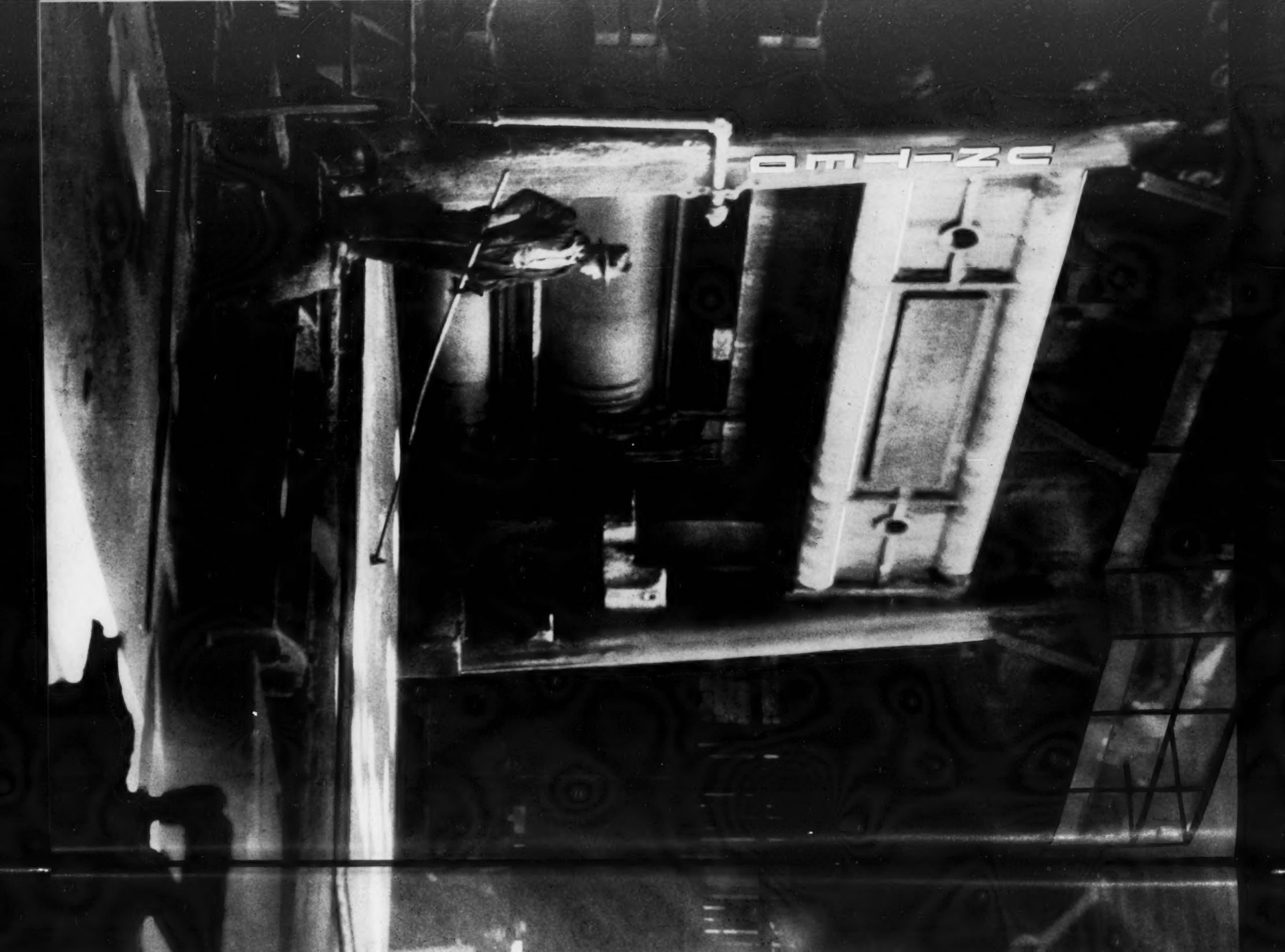
Today, the many cost-cutting, time-saving advantages of Yale Pumps are pledged to *victory*. Tomorrow, out of the trials and experiences of war, even more extensive peace-time uses for Yale Pumps can be foreseen.

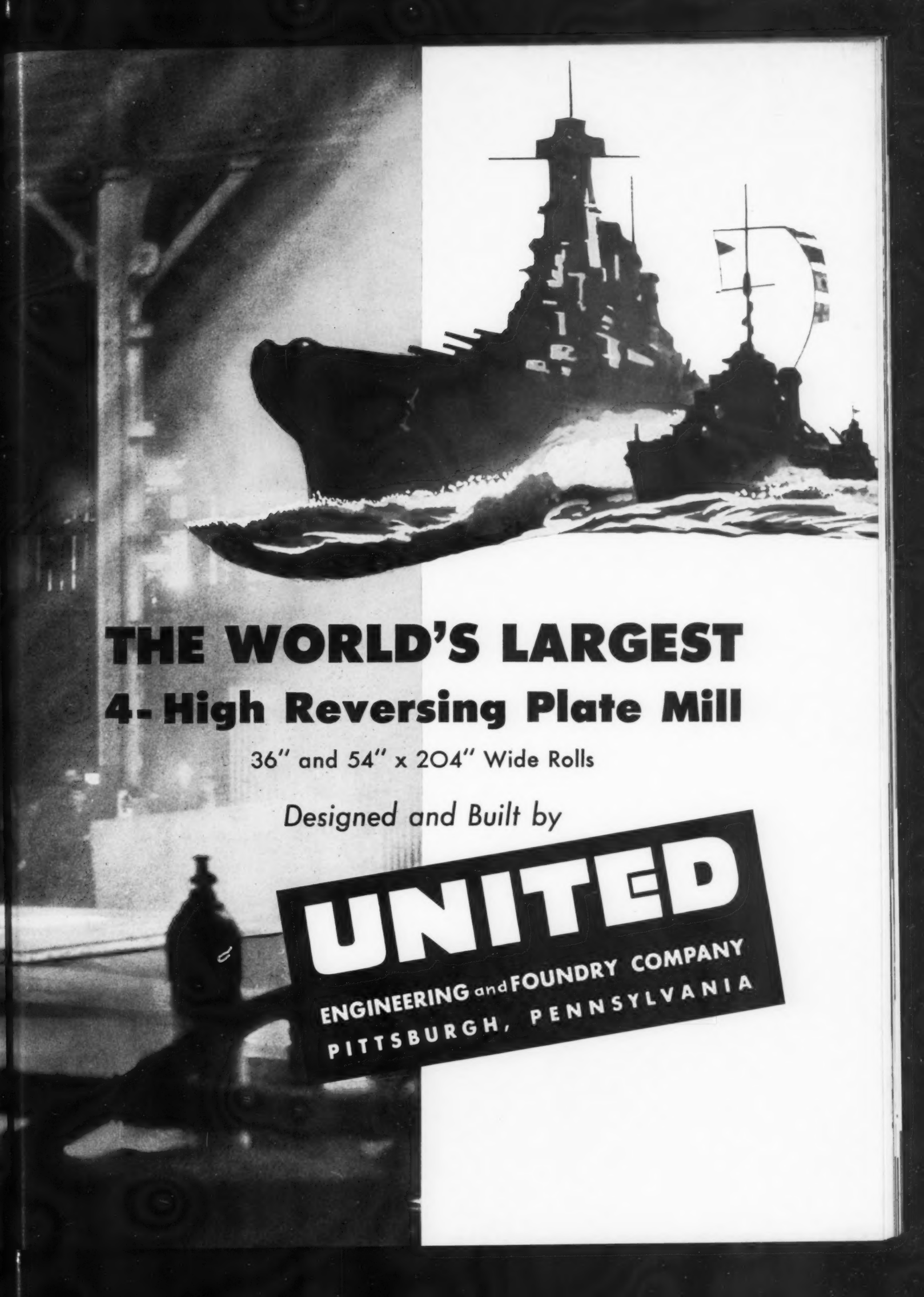
TRADE **YALE** MARK

THE YALE & TOWNE MANUFACTURING COMPANY

Pump Division

213 HENRY STREET, STAMFORD, CONNECTICUT, U. S. A.





THE WORLD'S LARGEST
4-High Reversing Plate Mill

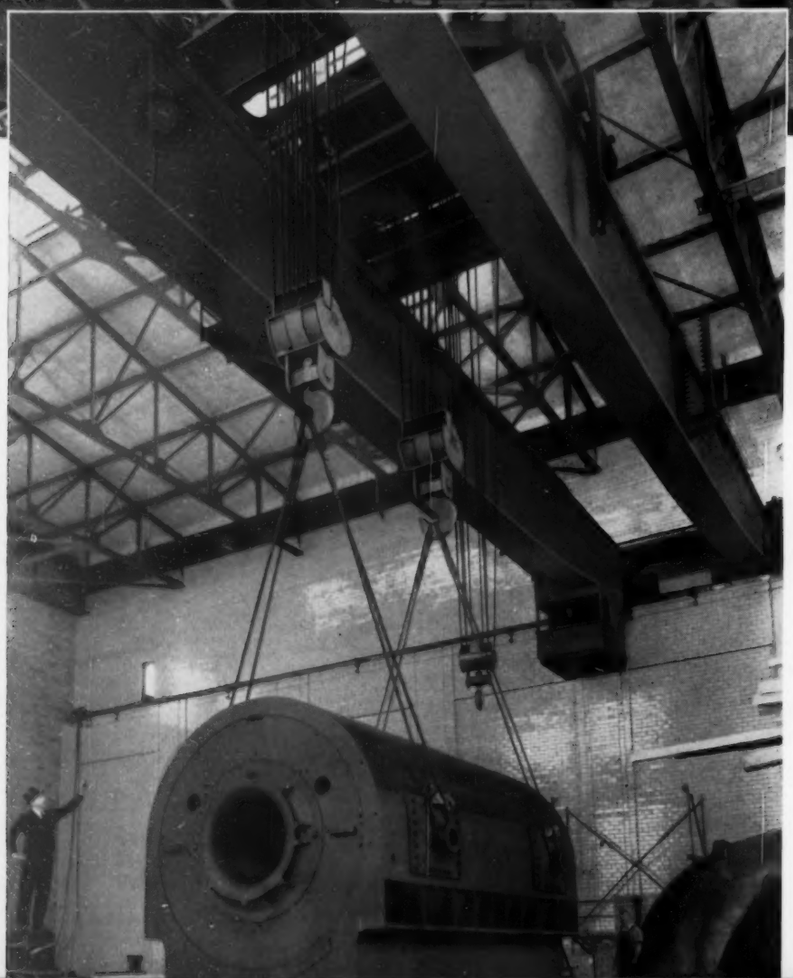
36" and 54" x 204" Wide Rolls

Designed and Built by

UNITED

ENGINEERING and FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA



150 TON-- 105 FOOT SPAN CLEVELAND *all-welded* CRANE

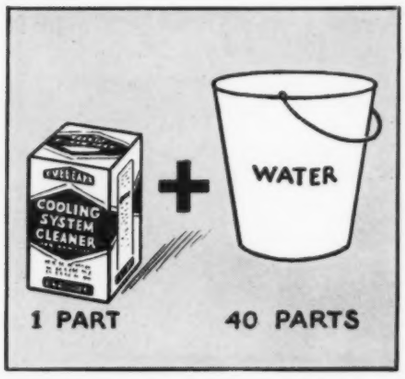
This is the largest all-welded crane ever built. Longer span Cleveland all-welded cranes have been made, many with spans up to 120 feet. But considering both span and capacity, the crane illustrated is the world's largest of the all-welded type.

The two girders for this crane are over 8 feet high at the middle and weigh 45 tons each. The entire crane weighs 178 tons.

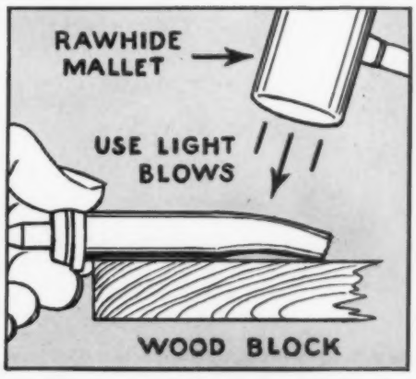
The all-welded crane has advanced tremendously since it was first pioneered back in 1926 by Cleveland Crane. It has grown up. Today, cranes of all sizes that can be fabricated by any method, can be built by welding. And if compared on a pound to pound weight basis, such welded cranes will be more rigid and stronger. This means easier handling, smoother riding and better all-around performance.

THE CLEVELAND CRANE & ENGINEERING CO.
1131 EAST 283RD STREET • WICKLIFFE, OHIO.

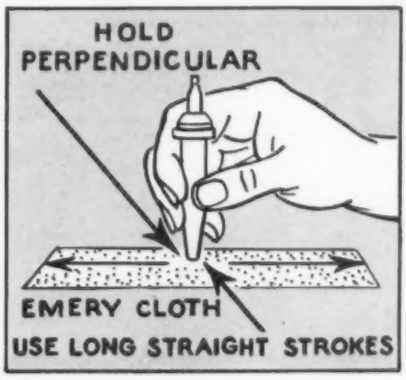
How to Recondition Oxy-Acetylene Hand-Cutting Nozzles



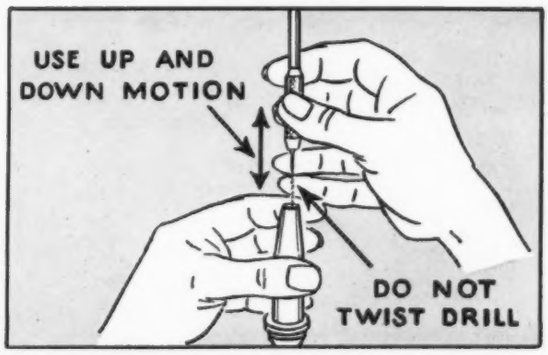
1. *Immerse the nozzle overnight* in a solution of 1 part "Eveready" automobile cooling system cleaning compound and 40 parts of water. Do not use the conditioner packed with the compound.



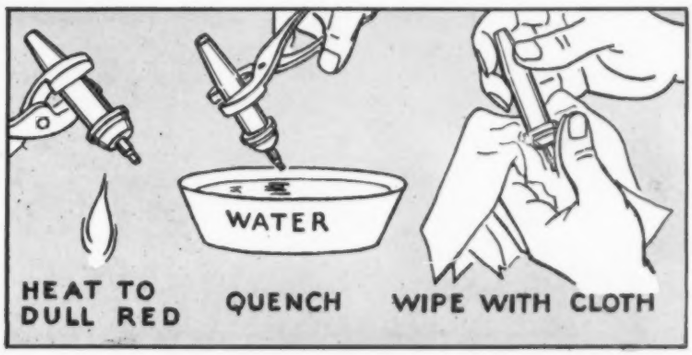
2. *If the nozzle is bent,* it usually can be straightened satisfactorily. To do this, place it on a wood block and straighten it by repeated light blows of a rawhide mallet. Do not use heavy blows.



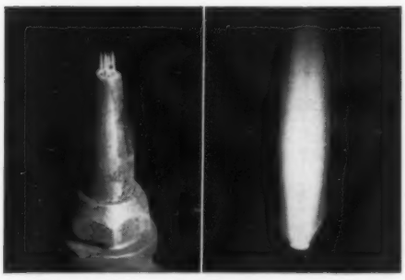
3. *Square Up the flame end* of the nozzle by rubbing it on Aloxite or emery cloth. Orifices must be round with sharp edges and no burrs. As much as ¼ in. can be removed from the nozzle end.



4. *To clear gas passages,* select the correct size drill—as specified in the blowpipe instruction book—and proceed as illustrated. Work the drill up and down carefully—do not twist it. If the drill does not enter the orifice easily, do not force it — start with smaller sizes. The last inch of the gas passages must be clean, to size, *and not bell-mouthed.*



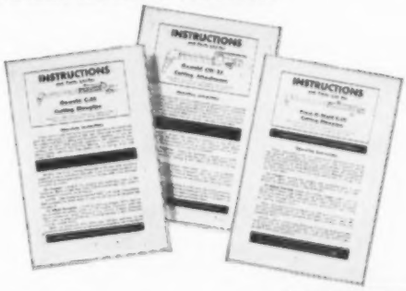
5. *To clean the nozzle seats,* heat up the seat end below the nozzle nut ring to a dull red heat—then quench in water. This loosens the scale so that it can be wiped off with a damp cloth. The heating softens the nozzle seats somewhat so that when connected to the blowpipe, they are burnished and dressed by the harder seating surfaces in the blowpipe head. If there are dents or nicks which are not eliminated by this procedure, the nozzle should be discarded.



6. *Test the flames.* Preheat flames should be uniform and the cutting oxygen jet symmetrical. Short preheat flames indicate restrictions in the gas passages. If the flames snap out when the valves are closed, the orifices are bell-mouthed.

Send for Instructions

If duplicate copies of the instruction booklets furnished with your Oxweld, Purox, or Prest-O-Weld apparatus will be helpful to you, we will send whatever copies you require. Be sure to specify the type of equipment you have. You may also obtain any required quantity of reprints of this advertisement.



THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 East 42nd St., New York, N. Y. UCC Offices in Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

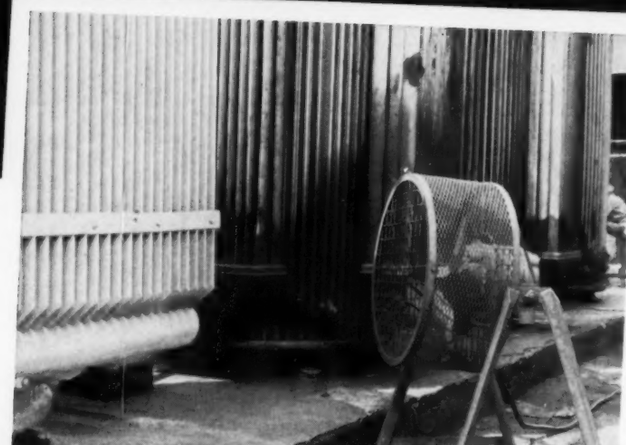
LINDE OXYGEN . . . PREST-O-LITE ACETYLENE . . . UNION CARBIDE
OXWELD, PUROX, PREST-O-WELD APPARATUS . . . OXWELD SUPPLIES

The words "Linde," "Prest-O-Lite," "Union," "Oxweld," "Purox," and "Prest-O-Weld" are trade-marks of Units of Union Carbide and Carbon Corporation.

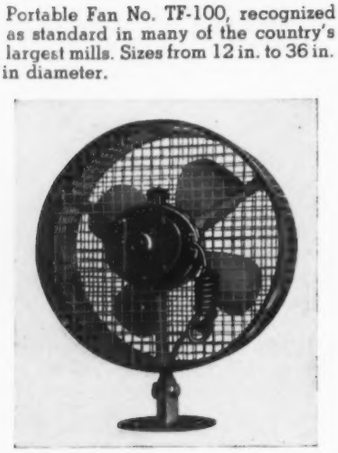
Let Truflo Fans . . .

Help keep your workmen on their toes

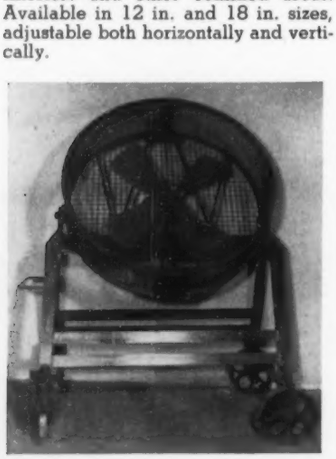
Portable Fan No. TF-100, recognized as standard in many of the country's largest mills. Sizes from 12 in. to 36 in. in diameter.



Portable Fan No. TF-300 in operation, cooling large transformers in strip mill.



Crane Cab Fan, for cooling crane cab interiors and other confined areas. Available in 12 in. and 18 in. sizes, adjustable both horizontally and vertically.



Portable Fan No. TF-300W. Angle iron support adjusts for vertical or horizontal discharge through almost 360°.

It's more important now than ever before to keep your workmen comfortable. For comfortable workmen are more efficient, produce more work in a given time.

Truflo Fans can help you keep your workmen on their toes. All Truflo Fans are designed and built correctly for efficient, economical operation — they move more air per dollar. Write for free literature on any of the following styles:

Portable Cooling Fans • Crane Cab Fans
Wall Fans • Exhaust Fans • Blowers
Roof Ventilating Fans • Pent House Fans

TRUFLO FAN COMPANY

554 MAIN STREET HARMONY, PA.

SAVE OXYGEN!

▲ It is almost inevitable that in the rapid expansion of oxyacetylene welding and cutting, there should be a period when wasteful practices are prevalent. Furthermore, the wholesale addition of thousands of inexperienced operators has considerably aggravated this condition. There is no question that the conscientious welder or cutting operator is concerned about eliminating waste, when he knows its source. This article, therefore, is intended to serve as a "check-list" that will help all concerned in preventing a serious oxygen supply situation from becoming critical.

Keeping war production industries supplied with an unceasing flow of oxygen and acetylene for welding and cutting is no less essential than providing the metals needed for production. Demand for these gases has increased enormously. For some time, gas manufacturers have been hampered in their efforts to meet this demand by a shortage of cylinders to transport the gases. Now, there has arisen another source of concern. The oxygen production capacity of the oxyacetylene industry is being strained to the fullest extent, in attempting to keep abreast of constantly pyramiding oxygen requirements. In spite of additions and expansions of oxygen and acetylene plants, a critical situation faces this industry — and all industries consuming these gases — unless efforts are made by everyone to conserve, particularly in the use of oxygen.

A survey has revealed a considerable number of shop practices which might be disregarded in peacetime, but which today must be considered wasteful. These habits of yesterday, being largely unconscious, can be remedied only by a re-evaluation of the significance of such seemingly trivial practices as using the wrong size hose or torch tip, or opening up a full cylinder when a quarter-full cylinder stands idle.

The following list of recommended practices is based upon observations of correctable conditions in oxyacetylene welding and cutting shops. The elimination of wasteful practices will not only go a long way toward relieving the "tight" oxygen situation, and insuring an uninterrupted supply of gases, but will also prove economical to the individual shop where such conditions prevail. One shop, for example, was found to be unconsciously wasting approximately 25 per cent of its oxygen consumption, through an accumulation of "insignificant" losses.

Use proper size tip.

1. *Use the proper size torch tip.* A No. 2 tip used instead of a No. 1 for cutting ½ inch plate consumes 10 to 20 per cent more oxygen, 16 per cent more acetylene — all wasted.

2. *Do not use excessive pressures.* This, one of the most common malpractices, is usually done by inexperienced operators who believe they thereby get a more efficient flame, or to save a trip to the pressure chart.

Avoid excessive pressures.

Manufacturer's rated pressures are the most efficient for average conditions. And when more speed is desired, the new high speed machine cutting tips cut faster without consuming additional oxygen.

3. *Close cylinder valves when torch is not in use.* If only the torch valves

Close cylinder valves.

are closed, gas pressure in the hose rises and may force leaks. If leaks are already present or if new leaks are forced, considerable gas will be lost.

4. *Check hose and connections for leaks.* They may be infinitesimal, but a $\frac{1}{64}$ inch diameter leak in hose operating at 100 psi will waste 290 cubic feet of oxygen in 24 hours — more

Check for leakage.

than a tankful. The hose should be checked periodically by immersing it in water while under pressure, to show up leaks. Soap and water will reveal leaks at connections.

5. *Use correct diameter hose.* Hose that is too small for the job requires higher gauge pressure to secure sufficient flow, causing unnecessary strain and promoting leakage in the hose.

6. *Use short lengths of hose.* Unnecessarily long hose also requires higher pressure, to overcome pressure drop in the hose. Also, the surplus lengths, though useless for the job, are subjected to unnecessary wear and tear.

7. *Use all the gas in each cylinder before connecting a new one.* Use every cylinder for all it is worth before disconnecting it. In the larger shops interruptions of work to change tanks can be eliminated by manifolding gas cylinders, or by installing pipe lines.

8. *Keep cylinder inventories low.* The old custom of keeping plenty of reserve cylinders must be abandoned, for it "freezes" them at a time when rapid turnover is imperative.Gas suppliers are cooperating by providing frequent deliveries. You can help by ordering fewer cylinders oftener, and by keeping reserves of cylinders at a minimum.

9. *Return empty cylinders promptly.* Idle cylinders are production slackers.

10. *Don't leave torches burning when not in use.* It may seem troublesome to be constantly re-lighting the torch, but if it burns idly for even as little as 3 minutes out of each hour, it is wasting 5 per cent of its gas consumption. Five per cent of last year's industrial oxygen consumption was 360 million cubic feet. Let's use those 1,636,000 tankfuls for welding and cutting, not for heating the air.

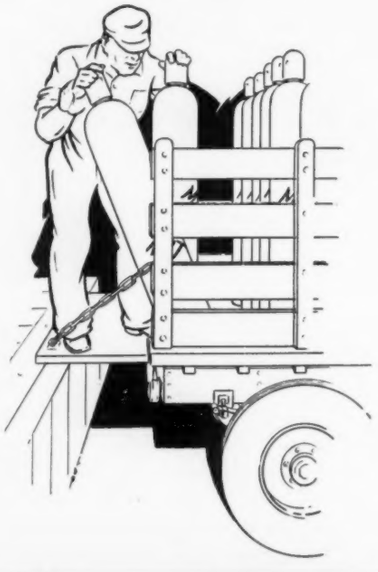
11. *Keep tips clean and free from carbon and slag.* An unclean tip is an inefficient tip, and, like any dull tool,

Use short hose lengths.

Keep inventories low.

▲

Return cylinders promptly.



Turn out torches not in use.

Keep torch tips clean.

Handle hose with care.

is abhorrent to the skilled workman. Congested orifices nullify the value of using proper pressures and speeds, resulting in lower efficiency and consequent waste of gas.

12. *Don't abuse cylinders.* A damaged cylinder must be taken out of circulation. It contributes nothing while undergoing repairs.

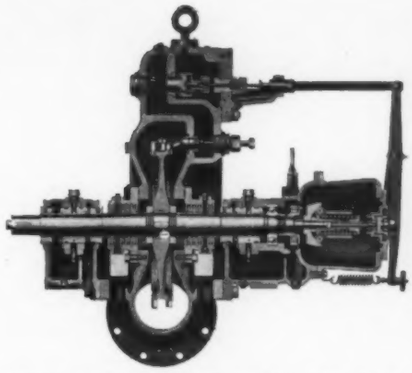
13. *Hose — handle with care.* Because hose is made of rubber, it is most important that it be made to last as long as possible. To insure this, it must be protected against mistreatment which promotes leaks. Therefore: keep hose out of range of hot oxide and sparks; wash off oil and grease, which ruin rubber; place a plank on each side of the hose where it crosses truck runways; store any hose stocks in a cool, dark place; and when a hose is damaged, cut out the bad portion and splice the ends together with standard splicing hipples.

Essentially these suggestions involve but one basic concept — to uproot yesterday's habits to meet today's demand. None of the recommendations is difficult to accomplish provided we open our eyes to everyday practices which should no longer be tolerated. Industry needs many waste wardens; they may be unofficial, they may be self-appointed, but if they watch out for wasteful practices among themselves and their co-workers they will be performing a very real service.

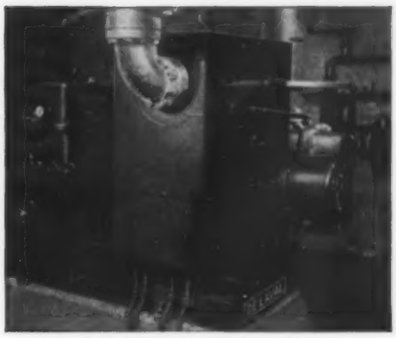
(The foregoing was prepared by Air Reduction Sales Company, New York, New York.)

TURBINES RE-DESIGNED

▲ The De Laval velocity-stage turbines illustrated in this article have been designed to meet modern conditions of steam pressure and temperature. Where used for driving auxiliaries, such as pumps and fans, they can in most plants be connected directly to the superheated steam main. The efficiency is as high as is attainable with a single pressure-stage and where the exhaust steam is utilized for heating and process purposes high overall economy is had.

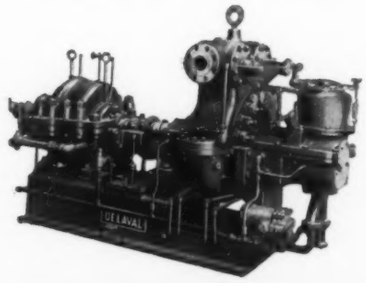


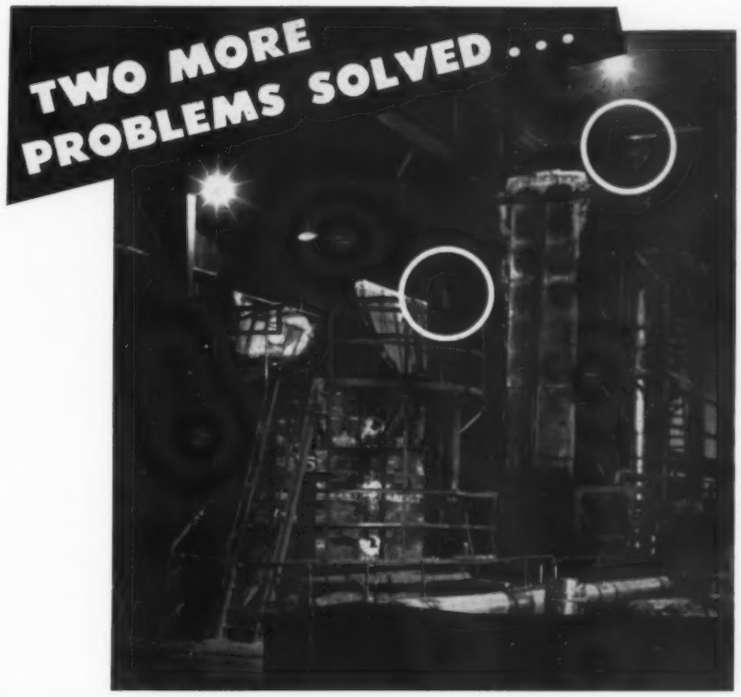
Section of velocity-stage turbine with shaft governor.



Velocity-stage turbine with helical speed reducing gear driving draft fan.

Velocity-stage turbine with vertical governor driving four-stage boiler-feed pump.





WITH RYAN DOOR HOISTS

Not only are Ryan Door Lifts adaptable to straight door problems, but they are equally efficient in taking care of special cases, like the pit furnace door lifts shown in the photograph. Special lifting problems are also handled for industry outside of the furnace door field.

Ryan Engineering Service also offers special limit controls for operation with car hearth furnaces, protecting against movement of the car before the door has passed through the safety limit. Consult us in relation to your stationary lifting problems.

Conserve time . . . . CONSULT RYAN!

ENGINEERED FJR EQUIPMENT

FRED J. RYAN COMPANY

LOCATED IN A PHILA. SUBURB . . . WYNCOTE, PA.

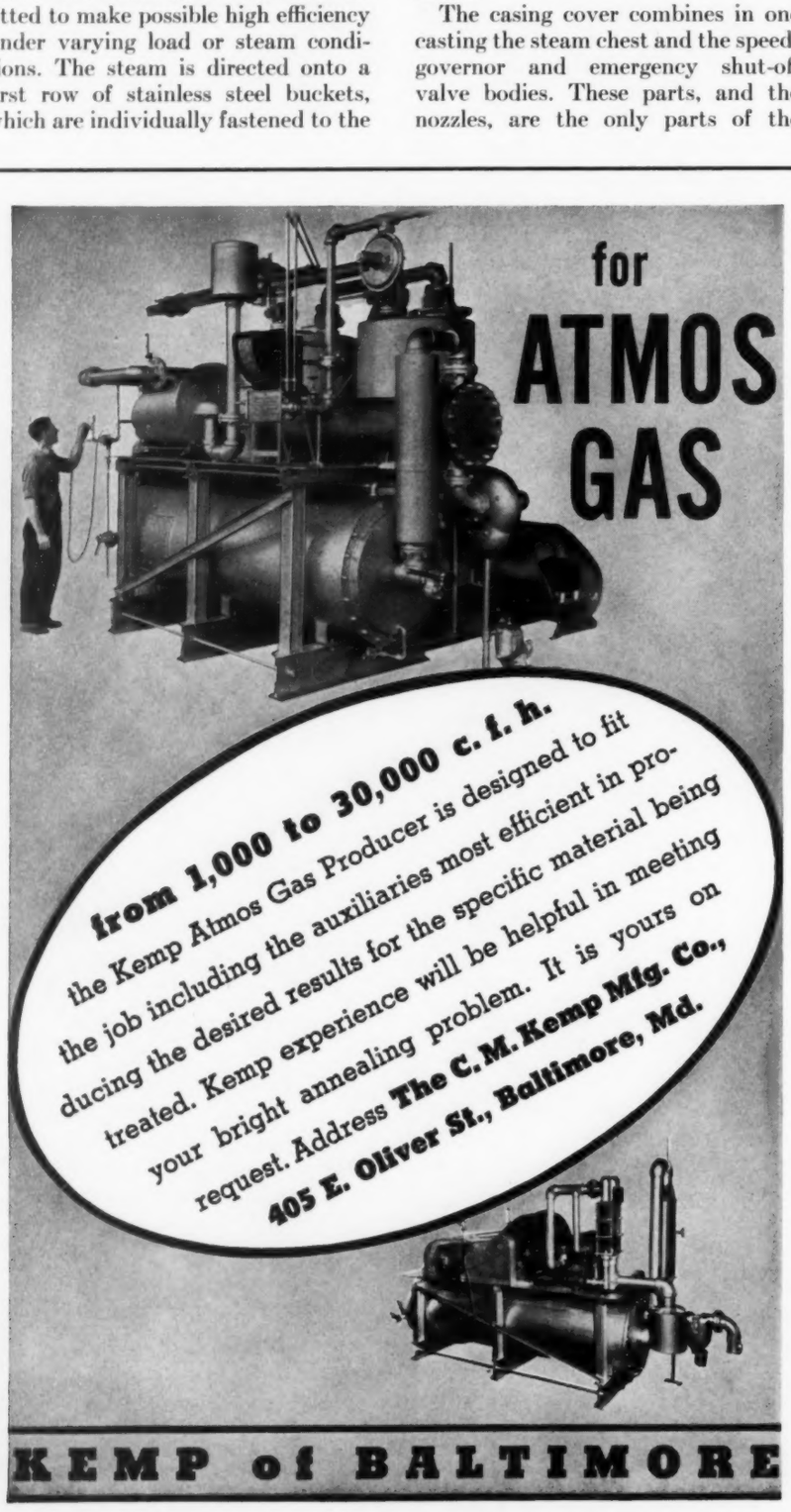
Steam expands from the initial to the final pressure in a single set of nozzles. The latter are made of stainless steel, accurately machined and reamed. They are screwed and welded into drop-forged steel bodies supported by the steam chest wall. Hand valves for individual nozzles can be fitted to make possible high efficiency under varying load or steam conditions. The steam is directed onto a first row of stainless steel buckets, which are individually fastened to the wheel. From these buckets it enters between stationary stainless steel guide vanes integral with and supported by the nozzles, which redirect it onto a second row of moving buckets, also of stainless steel. The buckets have large radial and axial clearances.

The casing cover combines in one casting the steam chest and the speed-governor and emergency shut-off valve bodies. These parts, and the nozzles, are the only parts of the turbine coming into contact with steam at the initial pressure and temperature and, where the pressure and temperature of the steam are high, they are made of cast steel. The lower half of the casing is also made of cast steel where required by high temperature exhaust conditions. The cover and attached parts are easily lifted to expose the wheel. There are no packed joints or cross-over connections to the lower half of the casing. Parts subject to the highest temperatures are remote from and above the shaft and bearings, resulting in lower temperatures of bearings and oil. For moderate steam temperatures the babbitt-lined bearings are lubricated by rings which carry up oil from reservoirs, but where the temperature of the steam at inlet or at exhaust is excessive, water-cooling or forced-feed lubrication can be provided. Also, an oil pump is provided for force-feed lubrication in high-speed turbines. The cast iron bearing shells are accurately machined and ground to fit seats accurately scraped to limit gauges. A ball thrust bearing locates the rotor axially.

The wheel is machined from a steel forging and is proportioned to withstand rotating speeds far in excess of normal. It is held by key and lock nut upon a shaft of liberal size. Steam or air leakage is prevented by packings on the shaft at each side of the casing. Each packing box contains four carbon rings, with an intervening space for steam-sealing or bleed-off.

The turbine has a centrifugal speed governor and an independent emergency tripping device consisting of an eccentrically loaded, pivoted ring which, at a predetermined speed, releases the independent emergency shut-off valve, which has a stainless steel stem. The valve can also be tripped and reset by hand.

The powerful and sensitive speed-regulating governor, consisting of flyweights pivoted upon rockers, is either mounted on the turbine shaft or, depending upon operating conditions, on a vertical shaft driven through a worm and worm wheel. The governing action is transmitted to the regulating valve through a ball thrust bearing and a lever mounted on a needle bearing. By adjusting a spring the speed can be changed while the turbine is running. Hydraulic governors also are used, particularly where the speed of the turbine is to be regulated to control the pressure or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ATMOS
GAS
from 1,000 to 30,000 c. f. h.
the Kemp Atmos Gas Producer is designed to fit the job including the auxiliaries most efficient in producing the desired results for the specific material being treated. Kemp experience will be helpful in meeting your bright annealing problem. It is yours on request. Address The C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore, Md.
KEMP of BALTIMORE

the rate of flow set up by a pump, a blower, or a compressor. The regulating valve is of the balanced, seating type and is actuated through a stainless steel stem packed with pure asbestos rings. The emergency closing and governor regulating valves are preceded by an accessible and removable steam strainer, consisting of a heavy, monel-metal screen.

The parts for these turbines are manufactured in quantities, using special jigs, gauges and fixtures, and are inspected by means of limit gauges to insure interchangeability and to eliminate hand-fitting. Each part is marked with symbols to certify inspection and for identification when ordering a duplicate part. After assembly a running test is made of each unit to insure satisfactory mechanical operation.

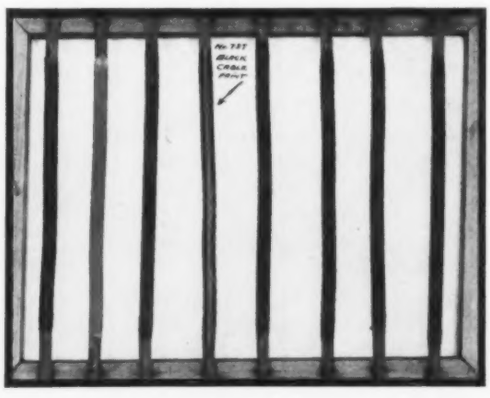
CABLE PAINT IS WEATHER RESISTANT

▲ After extensive research, the John C. Dolph Company has developed a black cable paint with excellent weather resisting properties. This paint, known as No. 737 black cable paint, is absolutely oil and waterproof, extremely flexible and flame resistant one hour after application to cable. It is also highly resistant to corrosive fumes and heat.

The illustration shows weathering effect on several taped cables after one year exposure to the elements on a test rack at 45 degree angle on a roof in an industrial district. This black cable paint still had a high degree of gloss and showed no indication of sunchecking or powdering upon conclusion of this test. Damage wrought by weathering is clearly visible on all other specimens, in the form of lack of glossiness, checking, etc.

For application to all cables, such as power, control, degaussing, motor leads, splices, etc. Black cable paint is supplied at heavy brushing consistency and provides a build up of 8 mils per coat. Air dries in 15 min and may be thinned with Dolph's 220 Thinner when necessary. Supplied in 1, 5, 30 and 55 gal containers.

View showing test rack in which cables were exposed to the elements.

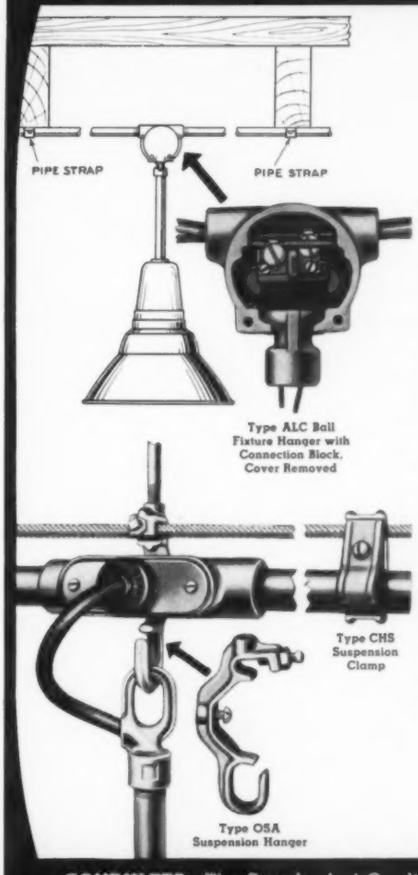


BUSHING OFFERS EASY INSULATOR RENEWAL

▲ Pennsylvania Transformer Company has designed a remarkable new heavy current bushing that will be the standard for the following bushing ratings: 500, 1000, 1500, 2000 and 3000 amp.

If an insulator is damaged during transportation, or during installation, due to rough handling, the insulator

Use **CONDULETS**, the easy-to-install conduit fittings, and **SAVE the TIME** of skilled electrical workers.


PIPE STRAP
PIPE STRAP
Type ALC Ball Fixture Hanger with Connection Block, Cover Removed
Type CHS Suspension Clamp
Type OSA Suspension Hanger

Flexible FIXTURE HANGERS

Several **Type AL Series Flexible Fixture Hanger Condulets** with the connecting thin wall or thick wall conduit may be assembled on the floor, raised to the ceiling as a unit and quickly fastened in place. The fixture may be wired on the bench and then hung by simply placing the ball of the hanger in the bottom recess of the Condulet, connecting the fixture wires to the connection block and attaching the cover. All the work of hanging is done in a vertical plane in front of the electrician.

Type AL Series Hangers are made in both the ball and cushion styles with several hub arrangements for thin wall threadless or thick wall threaded conduit. They can also be furnished with a fitting fastened to the top of the Condulet for either vertical rod or span-wire suspension.

Type OSA Suspension Hangers used with **Obround Condulets** provide another easy-to-install fixture hanger for rod or span-wire suspension. A plug and receptacle makes fixture removal quick and easy. The hook is so shaped that the fixture cannot be accidentally disconnected. One-wire hole covers can be used on the Obround Condulet, if the receptacle and plug connection is not desired.

A Nationwide Distribution Through Electrical Wholesalers

CONDULETS—The Standard of Quality in the field of electrical conduit fittings.

CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U. S. A.

Sales Offices: Birmingham — Boston — Chicago — Cincinnati — Cleveland — Dallas — Detroit — Houston — Kansas City — Los Angeles — Milwaukee — Minneapolis — New York — Philadelphia — Pittsburgh — San Francisco — Seattle — St. Louis — Washington
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On Roll Necks, Universal Couplings, Spindle Carriers, Table Rolls, Cranes and other tough jobs the many types of GATKE Fabric Bearings offer mighty aid in eliminating delays and avoiding costly machine shop work. An installation on your toughest service will show you. Write for particulars.
Gatke MOULDED FABRIC Bearings
GATKE CORPORATION - 228 N. La Salle - CHICAGO

can be readily replaced at a very small cost as it is not permanently fastened to the mounting flange or the copper rod.

An outstanding feature of this bushing, is the flexible connector at the bottom of the bushing stud. This flexible connector is made up of laminated copper. The laminations are constructed of copper .0010 (ten one-thousands) of an in. thick. The ends of these laminations (the section that makes contact) are tinned and sweated together to make a solid piece of copper bar. The curved parts of this connector have small separations between each individual lamination so as to give this connector flexibility.

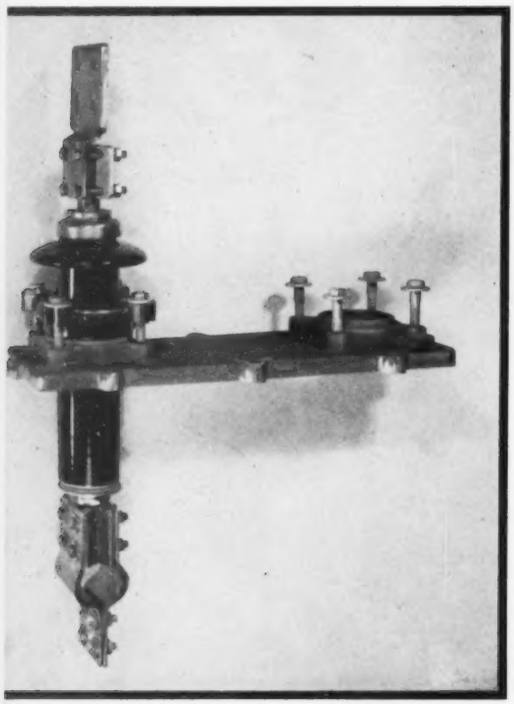
This flexible connector is designed to relieve any stress on the porcelain insulator that is caused by the expansion and contraction of the heavy coil leads due to heating and cooling.

The petticoat at the upper part of the insulator increases the creepage surface. The terminal is clamped directly to the copper rod.

All the contact surfaces are made on a smooth rod and are clamped with bronze alloy bolts and nuts, not depending on gaskets for maintaining contact pressures at any point on our bushing.

The rod which runs through the bushing is made of rolled copper.

This new heavy current bushing will be standard for 500, 1000, 1500, 2000 and 3000 ampere ratings.



BOOK HELPS BOOST PLATE PRODUCTION

▲ Steel plate shipments in May bettered the million-ton mark, surpassing by more than 100,000 tons the previous record made in April, the Iron and Steel Branch, WPB, announced recently.

May shipments totalled 1,012,194 tons of which 425,211 tons were made on continuous strip mills. This compares with 895,971 tons shipped in April, including 337,519 tons from strip mills.

Deliveries to shipyards for Maritime Commission orders topped 300,000 tons.

Further conversion of continuous strip mills to plate production now is underway and further increases in plate output are expected in subsequent months. It has been stated by several prominent officials of the Iron and Steel Branch that this conversion and the consequent increases in plate production have been aided in a large degree by the A.I.S.E. book, "The Modern Strip Mill," published in 1941.

PROGRESS IN ARMOR PLATE EXPANSION

▲ J. L. Perry, president of Carnegie-Illinois Steel Corporation, U. S. Steel subsidiary, announced recently that facilities for the expansion of the corporation's tank armor production in the Pittsburgh district, will be completed before the end of the current year.

These facilities, costing more than $5,000,000 will enable the corporation to more than triple its present output of the principal tank hull parts of special armor plate, heat-treated, fabricated and ready for assembly at the nation's tank arsenals where emphasis is now on the welded units rather than the older riveted models.

Each tank armor set produced by the plant consists of more than thirty individual pieces of prefabricated armor plate, which, when assembled at the tank arsenal, form the main body of the completed tank.

Conversion of this plant, which was operated as a tin mill from 1901 until early in 1940, constitutes a stirring chapter in the industrial war program. Before the year 1940 came to a close, the old tin mill had been dismantled and new facilities for production of tank armor were installed.

Early in 1941, pilot sets were shipped from the plant, production began, and output increased steadily until the present expansion program was undertaken.

The expansion program in addition to necessary plant structures involves the installation of: ten 15 ft x 40 ft heat treating furnaces; three 17 ft x

48 ft plate quenching tanks; two abrasive plate cleaners; two roller leveler units; eighteen flame shape cutting machines; thirty-one flame softening machines; thirty-one brake presses (mechanical flattening presses); thirteen electric overhead traveling cranes; fifteen floor operated cranes; miscellaneous plate handling equipment and miscellaneous tools and tool conditioning equipment.

REPUBLIC LIGHTS BLAST FURNACE

▲ Completed five weeks ahead of schedule, the new blast furnace of Republic Steel Corporation was officially lighted on May 28.

Only 119 days elapsed between January 30, when the first piece of steel was swung into position, and May 28, when the furnace was blown-in.

The furnace is the first of those authorized by the Government in connection with the emergency program in the United States. It will be followed early next fall by Republic's second new blast furnace. The furnace will supplement the nation's supply of pig iron, vital to the prosecution of the war.

In addition to the furnace, there will be a new battery of by-product coke ovens, a boiler plant, a generating unit, a 3-mile-long, 60-in. water line, a huge gas washer and precipitators in which the dust from the furnace is washed, separated from the water and fed back into the furnace as raw material.

Van der Hoeven DISCUSSION

(*Continued from page 75*)

fear collapse of knife edges at temperatures below 2200 F in the oven and usually the oven temperature does not run that high.

The flue temperatures would eventually have to be reduced for a temporary shutdown anyway and this will keep doors and frames from getting too hot.

All ovens we have built with self-sealing doors have been as high as 2000 to 2200 F in the flues just prior to charging and we never had any trouble.

C. P. BETZ: I asked Mr. Cole the same question recently and he informed me of the fact that they heated up their ovens at Gary with the self-sealing doors in place, and no damage was done to the doors. The only recommendation he made was that you brick up the chuck doors.

H. V. LAUER: I would like to have a point cleared up by Mr. Wald. I don't know whether I understood him right.

In raising the percentages of low volatile coal in their mix, do they experience a lower flue temperature with the same finishing temperature of coke?

M. D. WALD: Yes. Of course, to bring out the point, there is a great variation in the finishing temperature of the coke. The finishing temperature of the coke with the higher percentage of Pocahontas coal was higher. The inference is, of course, that the reason for that is that it takes less heat.

H. V. LAUER: I raised that question because we have just had the reverse experience. As we raise our Pocahontas, we have greater input of heat.

M. D. WALD: Is that with southern coal?

H. V. LAUER: Yes.

M. D. WALD: Or Pennsylvania?

H. V. LAUER: No, that was southern coal.

FOR INTERCHANGEABLE MARKING USE . . .

The "Champion" STEEL TYPE HOLDER

The "Champion" steel type holder (Patented) permits rapid interchangeable marking of flat, curved, concave or convex surfaces . . . assuring alignment and perfect spacing of characters. Pressure of thumb on spring actuated button releases type for instant changing. Holder shown is hand style. Also made with shank, for press production marking.

Construction

Quick Changing

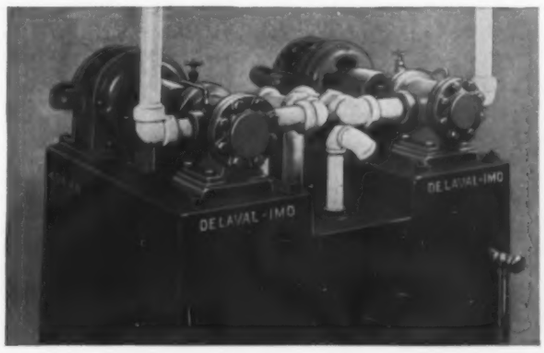
"Champion" Holders and "Tuf-Face" type are furnished in partitioned wooden boxes as illustrated, for easy handling and for keeping type in place. Cross-sectional view shows simple, fool proof type changing mechanism. Write for information and prices.

JAS. H. MATTHEWS & CO.

3982 FORBES ST. ∴ PITTSBURGH, PA.

New York—Chicago—Phila.—Boston—Detroit—Newark—Syracuse

DISTRICT SALES OFFICES • CLEVELAND • HARTFORD • BIRMINGHAM



DE LAVAL-IMO OIL PUMPS on Combustion Control

Hydraulic pressure oil to the combustion controls of the 2400 pound boilers in the Twin Branch Power Station of the Indiana & Michigan Electric Co. is supplied by these two De Laval-IMO oil pumps. This Station also has two other De Laval-IMOs for oil burner service, as well as De Laval centrifugal condensate, booster and hot well pumps.

Write for Publication I-89.

IMO PUMP DIVISION

of the De Laval Steam Turbine Company

Trenton, New Jersey

ITEMS OF INTEREST

R. F. Bergmann has been appointed chief engineer, Link-Belt Company, Chicago, succeeding **W. W. Sayers,** who has become consulting engineer. Mr. Bergmann had been assistant to Mr. Sayers from 1933 to 1936, when he resigned to become chief engineer, Rayon Machinery Corporation, Cleveland, from which position he now returns to Link-Belt.

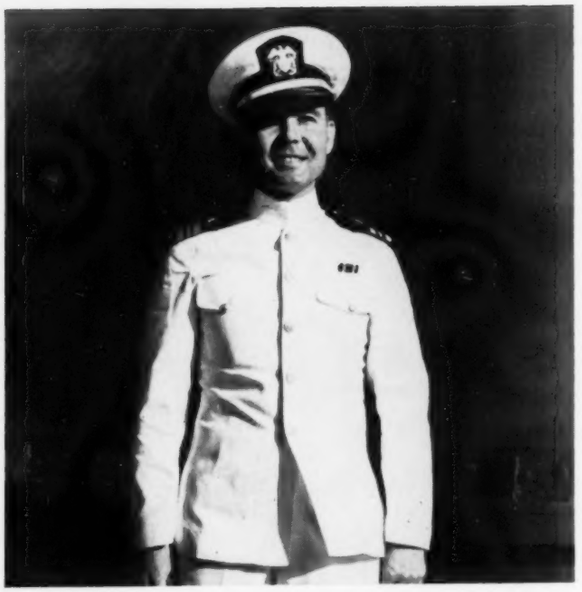
George H. Bendell has been appointed superintendent of factories at Joliet, Illinois, works of the American Steel and Wire Company, subsidiary of the United States Steel Corporation. At the same time **Henry W. Spitzhoff** has been named superintendent of the wire mill at Joliet.

E. C. Roberts, advertising manager of the Clark Controller Company since 1937, has been elected president of the Industrial Marketers of Cleveland. Mr.

E. C. ROBERTS

Roberts succeeds C. B. Cook, sales promotion manager of the Elwell-Parker Electric Company.

In colorful ceremonies on March 28th, Rear-Admiral W. C. Watts, USN, representing the Secretary of the Navy, presented the coveted All-Navy "E" pennant to R. C. Norberg, president of The Electric Storage Battery Company, manufacturers of Exide batteries. This was the first All-Navy "E" award in Philadelphia.



LIEUT. COMMANDER FRANCIS J. THOMAS

Lieut. Commander Francis J. Thomas, Republic Steel Corporation lubrication engineer recalled to active service in the Navy a year ago, has been given the Navy Cross for "heroism, courage, devotion to duty and gallant conduct" during the December 7 attack on Pearl Harbor.

A graduate of the U. S. Naval Academy in 1925, Mr. Thomas spent four years in the Navy before joining Republic in Buffalo. He has been in charge of lubrication for the corporation with headquarters in the Cleveland office since 1935. Mr. Thomas has been an active member of the Association for many years and has served as the head of the Lubrication Division.

Obituary

Chester A. Waite, assistant superintendent of plate mills, at Bethlehem Steel Company, Sparrows Point, Maryland, died suddenly of heart failure on May 31st. Mr. Waite, a member of the A.I.S.E., was 50 years old, and was associated with steel plate production for the past 21 years, having been previously connected with McCreath and Company.

WANTED — Mechanical and Electrical Engineers on steel plant construction. Location, Cleveland. Salary. Give full particulars and salary in first letter. Apply Construction Engineer, American Steel and Wire Company, Rockefeller Building, Cleveland, Ohio.

J-M SUPEREX

. . . the most widely used block insulation for temperatures between 600° F. and 1900° F.

Throughout the Iron and Steel industries, J-M Superex has long been recognized as the standard block insulation for temperatures up to 1900° F. behind refractory linings.

Made of high-quality, calcined diatomaceous silica, bonded with asbestos fiber and formed into large, easily handled blocks, Superex provides both high heat resistance and exceptional insulating efficiency. For complete information, write for IN-101A. Johns-Manville, 22 East 40th Street, New York, N. Y.

CHARACTERISTICS OF J-M SUPEREX

LOW THERMAL CONDUCTIVITY—the billions of tiny "dead air cells" in J-M Superex present a formidable barrier to the passage of heat . . . are largely responsible for its low thermal conductivity.

HIGH HEAT RESISTANCE—J-M Superex Blocks safely withstand temperatures up to 1900° F

LIGHT WEIGHT—Approximately 24 lbs. per cu. ft.

HIGH PHYSICAL STRENGTH—Withstands vibration and other physical abuse encountered in normal service. Approximately 4 tons pressure per square foot are required to compress Superex ⅛ inch.

PERMANENT EFFICIENCY—Superex maintains its high thermal efficiency indefinitely—will not disintegrate in the service for which it is recommended.

QUICK APPLICATION—The convenient sizes and light weight of Superex assure fast, economical installations.

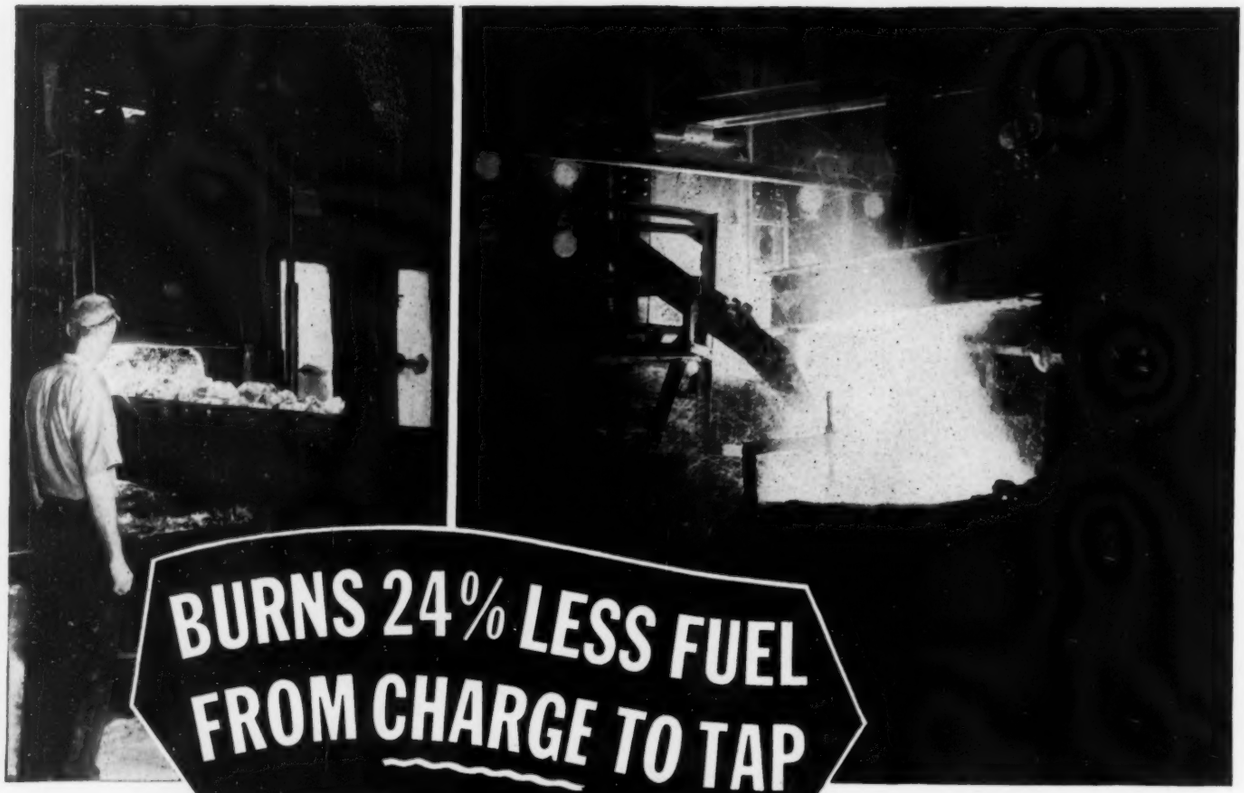
EASY CUTTING AND FITTING—Superex may be easily cut with an ordinary knife or saw for fitting around openings or irregular surfaces.

JM PRODUCTS

Johns-Manville INDUSTRIAL INSULATIONS

for every temperature . . . for every service

Superex . . . 85% Magnesia . . . Insulating Fire Brick (*4 types*) . . . Insulating Brick (*3 types*) J-M No. 500 Cement . . . Sil-O-Cel C-3 Concrete . . . Marinite.



BURNS 24% LESS FUEL FROM CHARGE TO TAP

with Hagan Open Hearth Furnace Control

DOES automatic combustion control on open hearths pay? The answer is—Yes! And here is direct proof from operating records.

A midwestern steel foundry recently installed Hagan Control on its No. 2 open hearth furnace. The immediate result—based on charge-to-tap figures for comparable two-month periods — was a reduction from 41.5 to 31.5 gallons of oil per ton of steel melted—a fuel saving of 24%.

Here is real pay dirt—and it's not just a flash in the pan. These are the actual figures for the bi-monthly periods in question:

GALLONS OF OIL PER TON OF STEEL MELTED
CHARGE TO TAP — WITH MANUAL OPERATION

August, 1939	**38**
September, 1939	**45**

CHARGE TO TAP — WITH HAGAN CONTROL

August, 1941	**32**
September, 1941	**31**

Average reduction with Hagan Control: 10 gallons per heat — a saving of 24%

What is even more important, a substantial increase in tonnage was obtained. Tap-to-tap time on a regulation 80,000-lb. heat was cut one and one-half hours over previous runs before the control was installed.

Comparable tonnage increases and fuel savings are obtained with every Hagan installation, depending upon the type of system and existing furnace conditions. In the case above, results were achieved principally by the installation of Hagan Control.

A simple, reliable means of stepping-up steel output in all types of heating furnaces, Hagan Control can be installed in relatively short order. Fuel savings usually pay for the control in a few months—then pay dividends.

We can increase your tonnage and reduce your fuel costs—and give you *better* steel, through more uniform heating, in the bargain. Let us prove it in *your* plant—call in a Hagan combustion specialist now!

HAGAN OPEN HEARTH FURNACE CONTROL PROVIDES:

1. **Fuel input control,** for regulation of heat input of the fuels burned.
2. **Fuel-air ratio control,** to admit air in exact ratio each fuel requires for best efficiency.
3. **Furnace pressure control,** by regulation of stack damper.
4. **Reversal control,** for furnace reversal on basis of time cycle, temperature difference, or both.

HAGAN CORPORATION · HAGAN BUILDING · PITTSBURGH, PA.

HAGAN *Automatic* COMBUSTION CONTROL

The pioneer . . . and still the leader

Iron and Steel Visits Warren

Under the sponsorship of its Pittsburgh and Cleveland District Sections, approximately 250 members and guests of the Association of Iron and Steel Engineers met in Warren, Ohio, on Monday, June 1. During the afternoon, Copperweld Steel Company graciously opened its Warren plant for an inspection trip. The dinner which followed was presided over by F. E. Flynn, shown (upper left) with D. G. Baxter. At upper right are shown H. M. Metcalf, J. P. Hutcheson, T. B. McElray, and F. H. Barnard, who were in attendance. The meeting was addressed by Mayor Roberts of Warren, shown (lower right) with W. B. Klee, Jr. The technical program which followed the dinner featured papers by W. J. Fleming and J. A. Succop (lower left).

ROLL TURNING & GRINDING
LET'S PUT HITLER THROUGH THE WRINGER !!
PERCENTAGE OF ROLLS CAST TO DATE
0 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% 110%
YOU DAMN YANKS HAVE CAST Plenty ROLLS THIS WEEK
QUOTA PER WEEK 100% PRODUCTION

Illustrative of industry's efforts to accelerate war production is the "production board" illustrated here. Boards of this general type, 8 ft x 12 ft, but of varied design have been installed in each department of the Lewis Foundry and Machine Division of Blaw-Knox Company. The idea for these boards was developed by the recently created management-labor committee and, along with other suggestions, the boards have proved helpful in stimulating greater production effort.

In recognition of excellence in the production of gear drives for Navy ships, the three plants of Farrel-Birmingham Company, Inc. at Ansonia and Derby, Connecticut and Buffalo, New York, have been awarded the Navy "E." Presentation of the award was made by Rear Admiral Henry A. Wiley, U.S.N., and was accepted on behalf of the company by Mr. A. G. Kessler, vice-president and general manager of the Buffalo plant.

▲

R. B. Nichols, vice-president and general manager of Bantam Bearings Corporation, South Bend, Indiana, accepts on behalf of Bantam employes second Navy "E" award given the company in six months for an outstanding record of production for the Nation's war program. Presenting the award are Lieut. Kenneth Keepers (center) and Ensign E. C. Dollard, representing the Navy Department.

Available Literature

▲ Leeds & Northrup Company has just issued a rather distinctive publication of general interest to engineers, research scientists, executives and users of electrical instruments, controls and furnaces.

Called "Modern Precision," it contains news of L&N instruments, controls and heat-treating methods, and

of the jobs they are doing in industry, in research laboratories and in teaching and testing. An addition to other L&N literature, it supplements the regular catalogs, bulletins and circulars which will continue to be issued as before.

▲ A four-page folder complete with engineering diagram describes the Trabon single pipe centralized system that lubricates all the connected bearings without employing any springs, diaphragms, packing or exposed moving parts. Proved design of "feeder" positively prevents any "skipping" or passing by of any connected bearing without lubricating it, by requiring that each feeder discharge to its connected bearing first in order to open up the port through which the lubricant flows on to the next feeder and bearing. Write to Trabon Engineering Corporation, 1814 East 40th Street, Cleveland, Ohio.

▲ "Foundry Work" (fourth edition), recently published by the McGraw-Hill Book Company, Inc., is a text on molding, dry-sand coremaking, melting and mixing of metals, and problems in foundry management, prepared by R. E. Wendt. Its 261 pages are divided into seven parts, covering the various phases of the subject. The book is intended to serve as a text for schools and colleges and for apprentices in commercial shops.

"I'm glad our cranes have CRANE motors"

"It's a real satisfaction to know that our cranes are designed to do *our* job in every particular. Built entirely in P&H shops, they're engineered as complete units with all motors and electrical apparatus designed solely for crane service — not adapted to it.

"It's good for my peace of mind to deal with a single, responsible supplier. To have no buck-passing on delivery or maintenance problems.

"That counts for something — especially during this emergency. And so do P&H's honest delivery dates."

P&H is America's largest and only crane builder producing complete electrical equipment.

Awarded the Navy "E" for excellence in war production, P&H displays it also as a pledge of future effort.

General Offices: 4455 W. National Ave., Milwaukee, Wis.

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CORPORATION
ELECTRIC CRANES • EXCAVATORS • ARC WELDERS P&H HOISTS • WELDING ELECTRODES • MOTORS

ROLLWAY'S RIGHT-ANGLED LOADING

Keeps Bearings Rolling 168 Hours a Week

NO
Compound Loads,
NO Complicated Stresses.
They Give Maximum Capacity in Minimum Space.

ABOVE —
TYPE MCS
Double Width Radial With Separable Outer Race.

RIGHT — TYPE DAT
Thrust Bearing Double Acting, Aligning.

Simple, right-angled loads carried on rollers of uniform cross-section . . . with no compound loads, no oblique loads to complicate the stresses . . . that's why Rollway's Solid Cylindrical Roller Bearings are tailor-made for the war-time 168-hour week.

All loads are uniformly distributed. All races are parallel to the roller axis. There's no pinching effect, no wedging of the rollers against the radius of the race. Sliding friction and wear-back of roller ends are held to a minimum.

Splitting the load into components of pure thrust and pure radial makes for compactness, hence you can change your present bearings to Rollway's of higher capacity rating in the same dimensional limits.

In no other type of thrust bearing can so much capacity be obtained in so compact a form. Short, accurately dimensioned rollers insure free rolling and low torque, regardless of the oil-film. And staggered position of the thrust rollers equalizes the distribution of wear.

STANDARD SIZES FOR MOST APPLICATIONS

Rollway's unusually wide range of series and types provides standard metric dimensions and tolerances for practically every design, providing both replacements and change-overs at lower cost. Send us your drawings—particularly your conversions—for free engineering analysis and bearing recommendations, a free service that's worth real money to you.

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BEARING COMPANY, INC., SYRACUSE, N. Y.

BUILDING HEAVY-DUTY BEARINGS SINCE 1908 **BEARINGS**

Foil fifth-column kilowatts

Kilowatts that shirk their work aid the enemy — waste power, obstruct output. Defeat disloyal kilowatts and prod production by correcting commutation faults. Let SPEER commutation engineers help you.

Sample reports of what happens after SPEER recommendations are adopted:

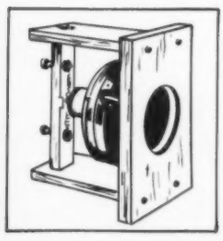
Never ran so well before
No one ever saw it spark since
Black spots and edge markings eliminated

Now taking full load — never before
Could not run without sparking before
No more trouble now
Carries more than 100% overload on peaks

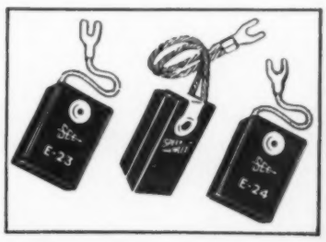
All you need do to get comparable results is to write for a set of SPEER Brush Data Forms — one for each machine you want to improve.

Fill out the forms and mail them to SPEER. On receipt, your help will be despatched promptly.

Famous American Firsts



Bell Magnetic Telephone. 1876



SPEER BRUSHES— To meet the requirements of most industrial motors, SPEER Electro-Graphitic Brush grades E-23 and E-24. Also available as Multiflex Brushes. Write today for complete descriptive catalog.
There is *one right* brush grade for every job—and SPEER makes it.

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QUICK CHANGES *are Easy*

with **P-G**...

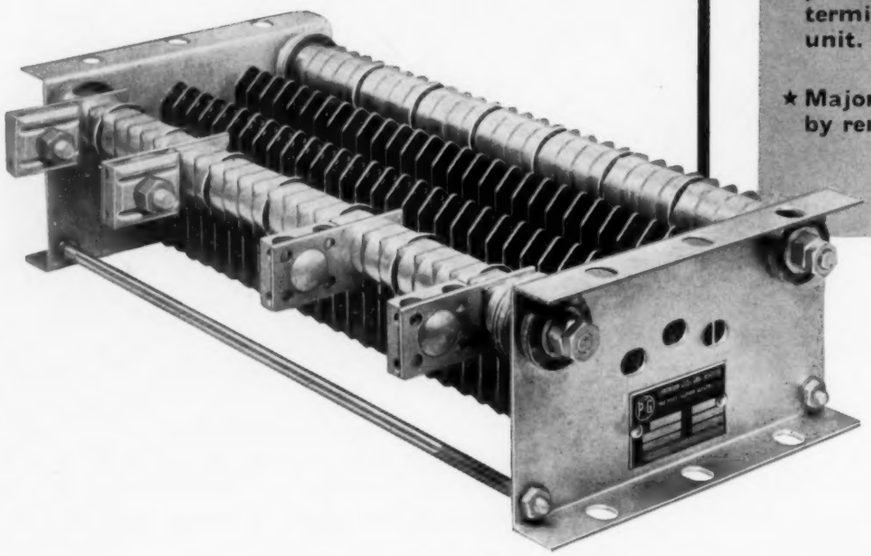
STANDARD RESISTOR UNITS

Little Effort Required To Make Adjustments

★ Minor variations often possible by wire change to other available terminals.

★ Greater variations easily produced by movement of terminal position in the unit.

★ Major variations effected by removal or addition of one or more standard banks.



OPERATING conditions change rapidly today. To meet new production schedules it may be advisable to adjust resistor layouts to do a better and faster job. P-G Standard Resistor Units already in use, and a few spares in the supply room, help in making needed alterations within a minimum time and with utmost efficiency. Normal adjustments can usually be accomplished within a few minutes. Detailed data about P-G Standard Resistor Units is listed in BULLETIN No. 500.

P-G

"The Resistor you can Install and Forget"

THE POST-GLOVER ELECTRIC COMPANY

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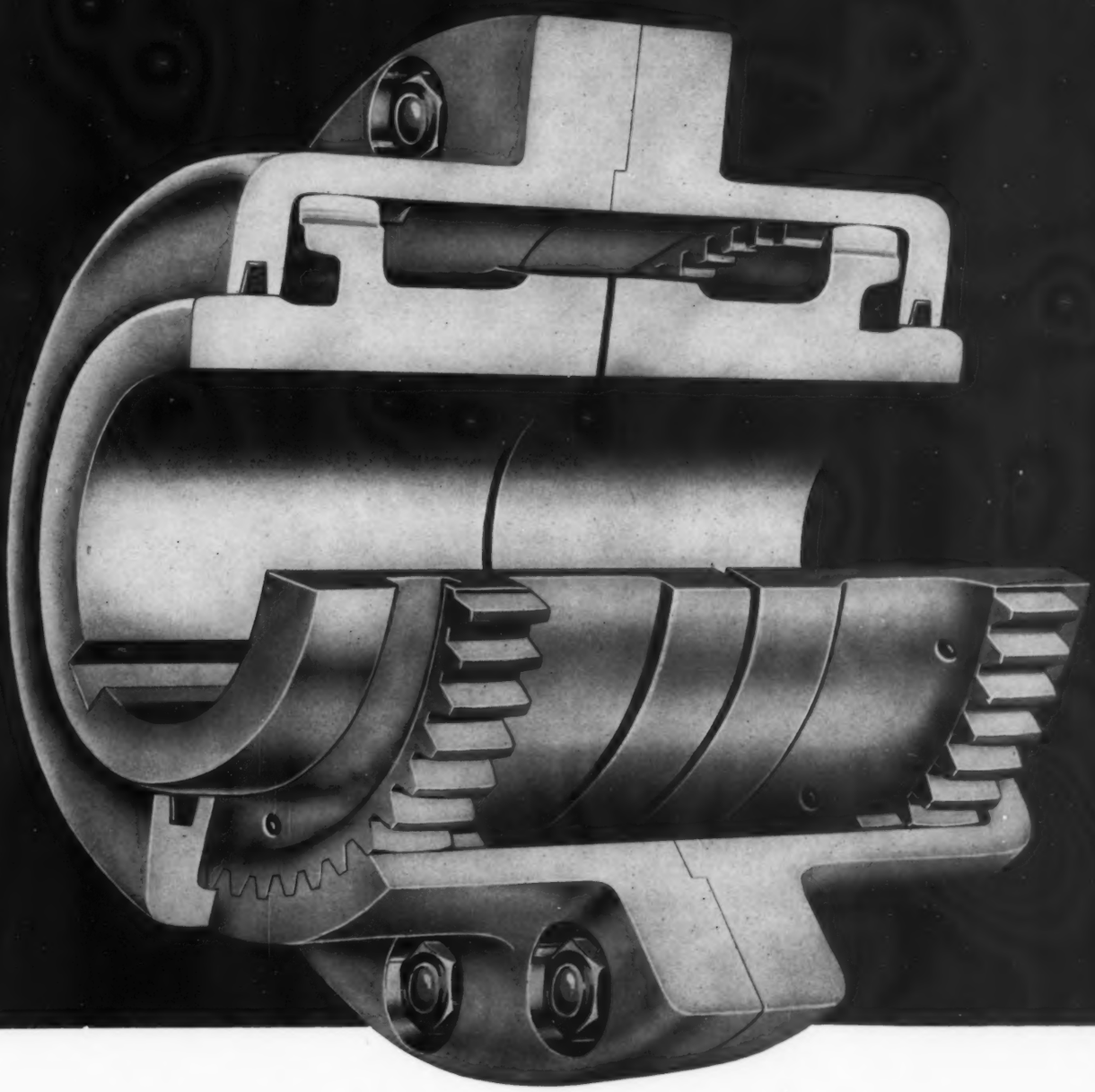
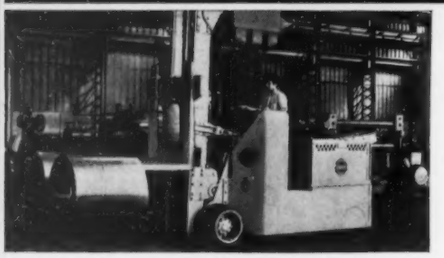


A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

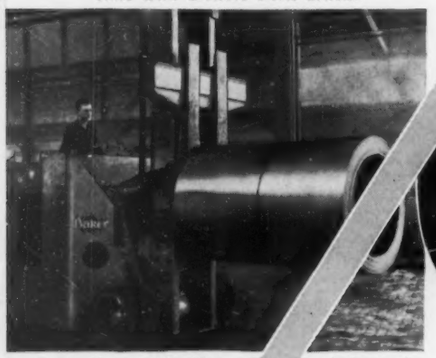
BAKER TRUCKS *Speed Steel Production*



Baker Heavy Duty Ram Truck handling two 8000 lb. coils of strip.

Two of the fleet of Baker Trucks in the largest stainless mill.

Sheet steel or tin plate handled two loads at a time with Double Fork Truck.

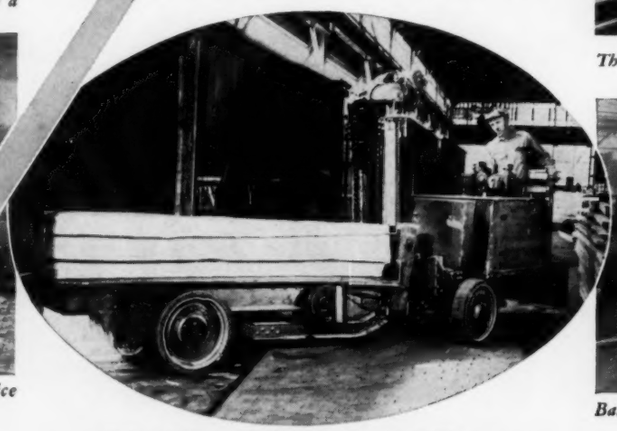


15,000 lb. capacity Baker Ram Truck in service at a large hot strip mill.

● Steel mills, already taxed to their apparent limits are today called on to deliver more and more of the essential basic materials from which our War equipment is fashioned. Baker Trucks are helping them solve their problems—increasing plant capacities without expansion by more efficient handling of materials, lower manufacturing costs, faster loading and unloading of cars, and by utilizing every available foot of storage space.

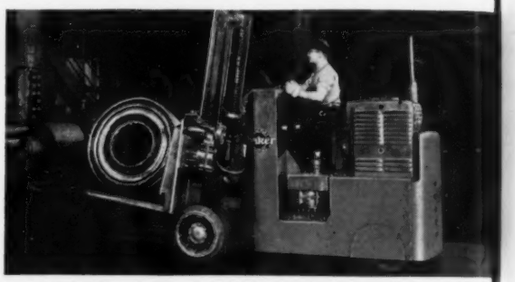
There is a Baker representative near your plant who knows material handling. Let him determine how you can use Baker Trucks to their best advantage —or write us direct.

BAKER INDUSTRIAL TRUCK DIVISION
of The Baker Raulang Company
2166 WEST 25th STREET • CLEVELAND, OHIO

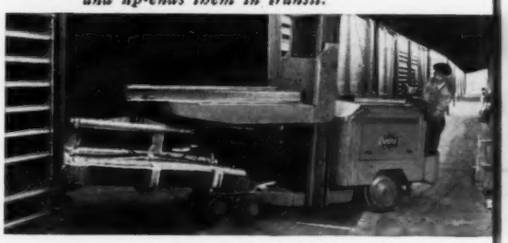


Baker Articulated Sheet Handler loads 200 tons per hour—saves $4.30 per ton.

Wire mill cuts loading and handling time with Baker Crane Truck.



This Baker Fork Truck picks up six ton coils and up-ends them in transit.

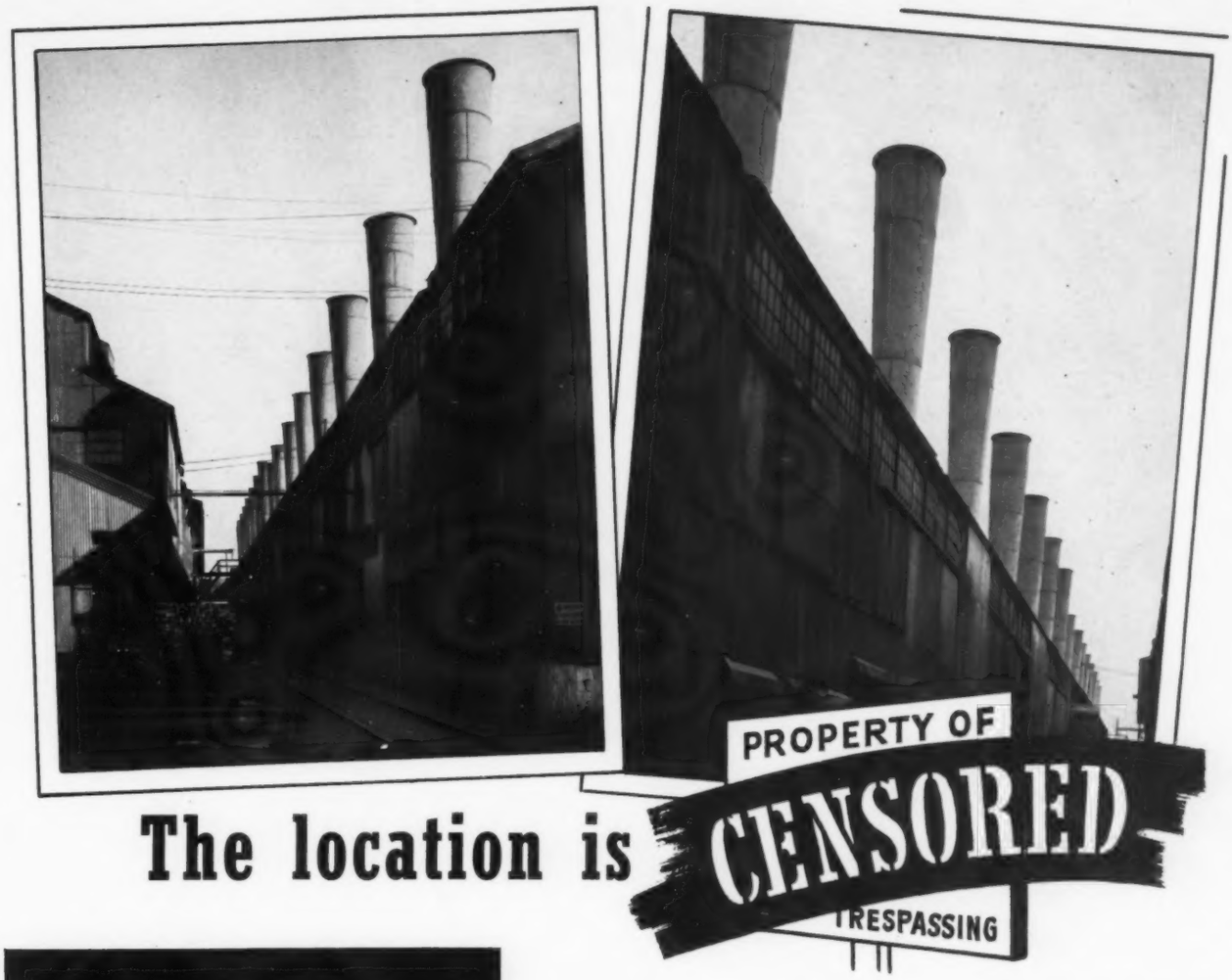


This Baker Truck with swivel cut loading costs from $28.00 to $5.00 per car.

Baker Tractors move many tons of steel in single or multi-trailer trains.

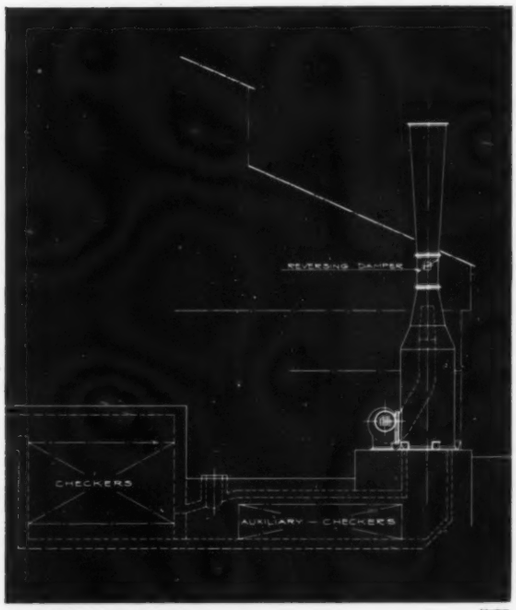
Baker INDUSTRIAL TRUCKS

In Canada: Railway and Power Engineering Corporation, Ltd.



The location is

but the results are OUTSTANDING



V-38

Compare these photographs with those of any old-fashioned open hearth installation! Note the *absence* of high stacks and the substitution of the short venturi tubes of the Isley Regenerative Combustion Control system. Think of the *savings* in installation and maintenance costs; the all-important *time* earned for extra production. Consider the *economy* in labor and material . . . all these are apparent in these pictures.

But the real reasons for twelve years of ISLEY expansion by this company are found *inside* the plant. For with Isley Regenerative Combustion Control the company has increased the temperature of its combustion air with enlarged regenerative capacity.

It has obtained greater efficiency from fuels, closer control of furnace temperatures, with more tons per hour and more heats per campaign. It has assured uniform operation of each open hearth—day or night, winter or summer, regardless of outside temperature and humidity.

The full ISLEY story is told very simply—practically at a glance—in our new bulletin "Push and Pull." Write for a free copy.

MORGAN WORCESTER ENGINEERS AND MANUFACTURERS

Morgan Construction Co.
Worcester, Massachusetts

European Representative: **International Construction Co., 56 Kingsway, London, W. C. 2,— England**

ISLEY Regenerative Combustion Control

Urgent

An Open Letter to Executives on the Subject of the Critical Scrap Shortage

INLAND STEEL COMPANY
CHICAGO

OFFICE OF THE PRESIDENT

Gentlemen:

Much has been said and done about the great need for more scrap to keep the steel mills running, but do you men who have control in your various plants and factories realize the gravity of the situation?

The steel industry is hoping to produce 88 million tons or more during 1942. To make this amount of steel will require a minimum of 30 to 40 million tons of scrap iron. We used to figure about 55% scrap and 45% pig iron. Now we are using less scrap and more pig iron, but with blast furnaces running 24 hours a day producing all the pig iron possible the only way we can increase our production is to get more scrap. We must not only get enough scrap to carry on this summer, but we must build up a back-log that will carry us through the winter.

Sometime ago we made a drive to clean up scrap on our own plant and secured a substantial tonnage. However, I was not satisfied and six months later authorized divisional managers to junk everything that they did not absolutely need in the operation of the business. This second check produced more than double the first cleanup.

I tell this story because I believe the same situation may exist in your plant. In time of war it is inconceivable to me that anyone with the authority to scrap unused equipment, dies, jigs, forms, moulds, etc., would not do so at once. Our boys at the front need steel with which to fight, need steel for protection. Your scrap steel will help save their lives and help win this war more quickly. So I urge you not to hold back. Scrap it now--tomorrow may be too late.

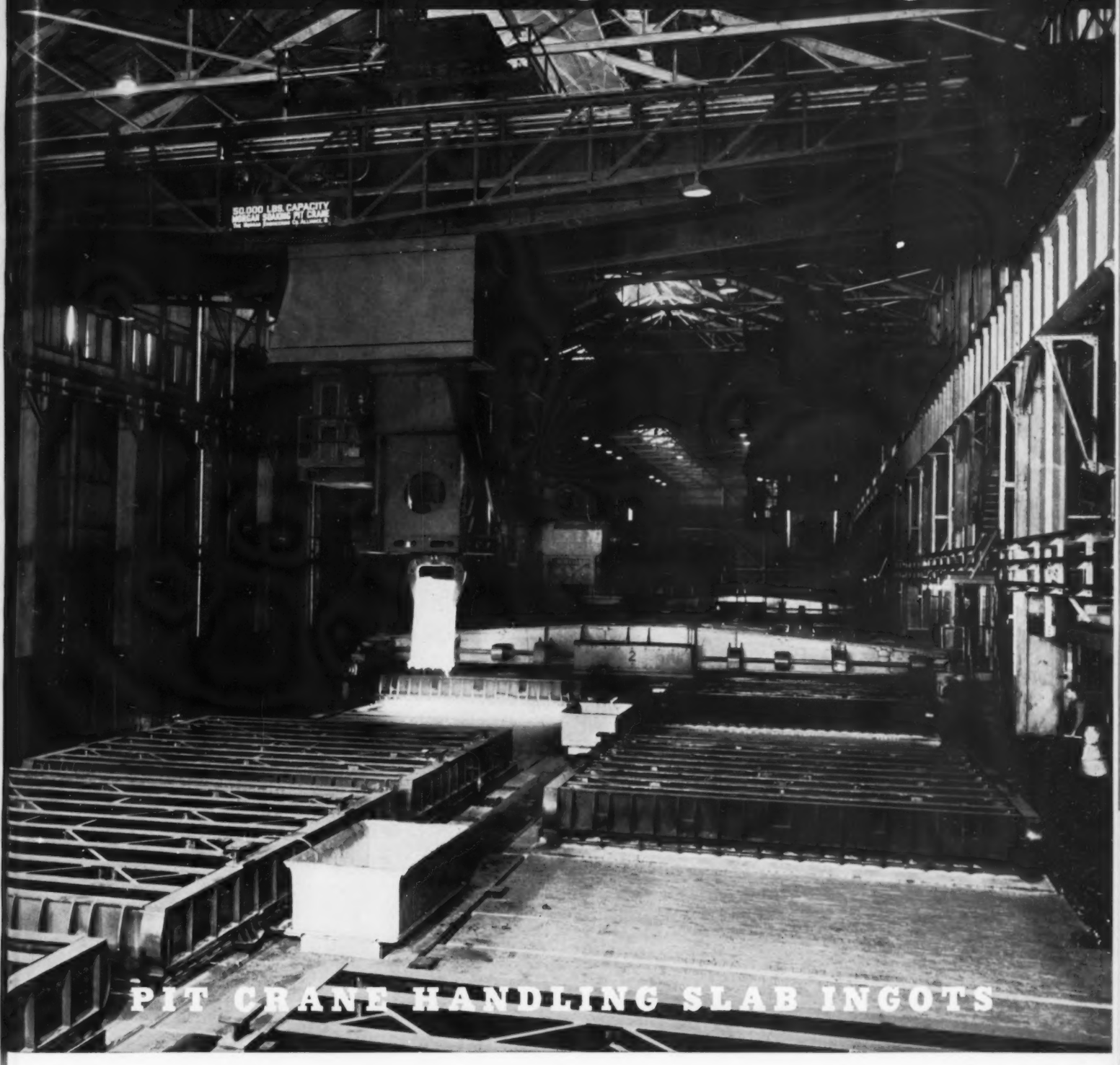
Sincerely,

W. Sykes

W. Sykes, President
Inland Steel Company

INLAND STEEL CO.

BUILT BY MORGAN *Engineering*



PIT CRANE HANDLING SLAB INGOTS

● Illustrated are three Morgan 25-ton, 95′-2″ span modern soaking pit cranes handling slab ingots for one of the world's largest strip mills. Equipped with worm-operated trolleys and anti-friction bearings, coupled with Morgan stamina of design and construction, these cranes will render many years of profitable service. Long service life is, of course, based upon sound engineering, the best materials and correct fabrication methods. Morgan soaking pit cranes forty years old, and over, are in successful operation today—slower, less efficient than a modern Morgan crane of latest type as illustrated, but still operating with their original dependability.

★ **DESIGNERS • MANUFACTURERS • CONTRACTORS**

BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS

★ ELECTRIC TRAVELING CRANES • CHARGING MACHINES

INGOT STRIPPING MACHINES • SOAKING PIT CRANES

★ ELECTRIC WELDED FABRICATION • LADLE CRANES

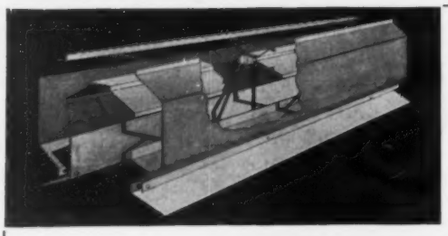
STEAM HAMMERS • STEAM HYDRAULIC FORGING

★ PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

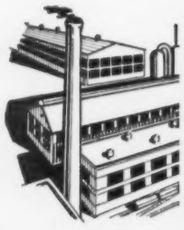
THE MORGAN ENGINEERING CO., Alliance, Ohio

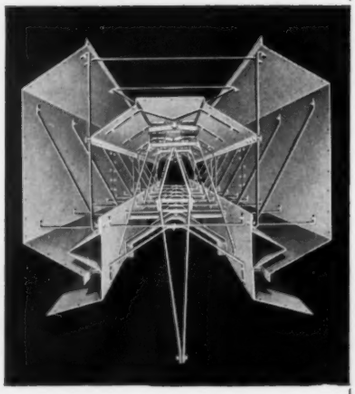
Pittsburgh, 1420 Oliver Building

★



Cutaway View





BURT MONOVENT

Continuous Ridge VENTILATOR

Protects Workers From Heat Fag

Keep hot and fume-laden air constantly moving out through the Monovent ridge ventilator and you contribute immensely to the comfort and increase the efficiency of your workers. By utilizing the entire ridge or apex of the roof, Monovent affords extraordinary capacity and uniformity of air flow.

Monovent costs less than unit ventilators and presents finer appearance. Will not clog with soot and cinders. Takes fullest advantage of wind action. Storm proof, designed to prevent backdrafts. Fits any type, any pitch of roof. Comes in ten-foot lengths, easy to install. Requires no tailoring on the job. Supplied in all materials, including asbestos-protected steel. Write for detailed data and job references.

THE BURT MFG. CO.
ROOF VENTILATORS • OIL FILTERS
EXHAUST HEADS
850 SOUTH HIGH STREET AKRON, OHIO

SEND FOR CATALOGS
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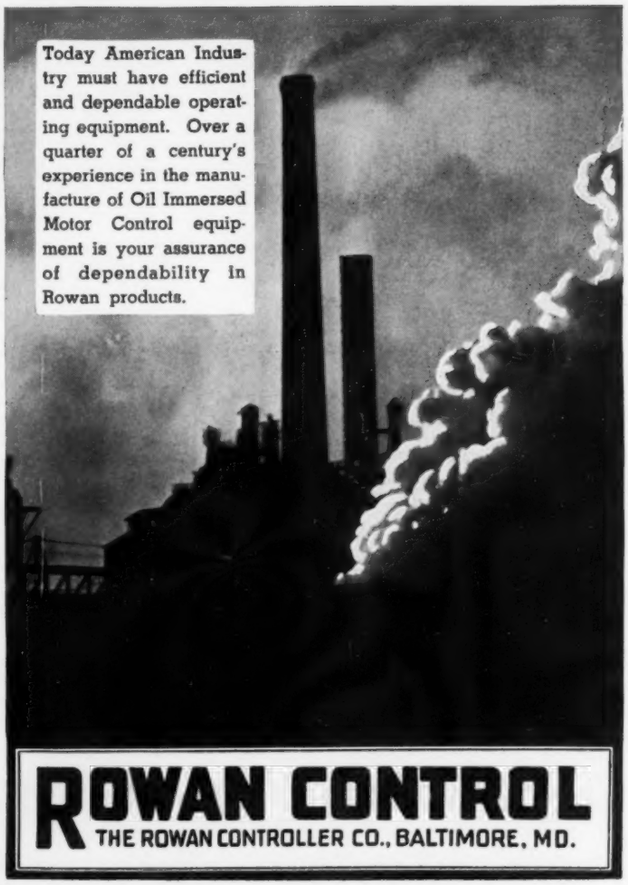
Burt Engineers are glad to help on plans

ROWAN
Oil Immersed MOTOR CONTROL

OK

BY USERS EVERYWHERE

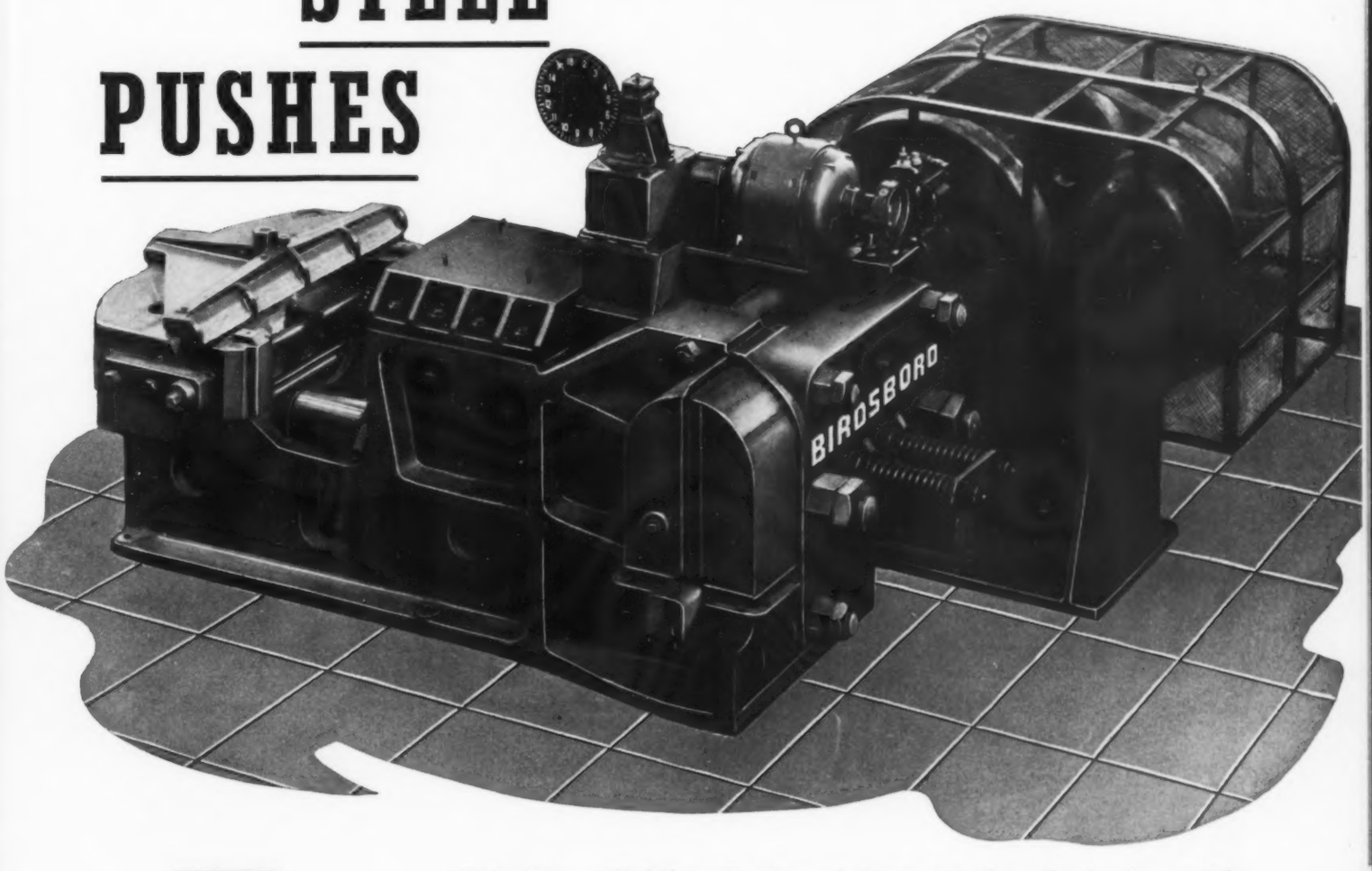
ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.



Today American Industry must have efficient and dependable operating equipment. Over a quarter of a century's experience in the manufacture of Oil Immersed Motor Control equipment is your assurance of dependability in Rowan products.

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

UP! PRODUCTION STEEL PUSHES



FEATURES

Pressure — 600 tons

Capacity — Round and square bars up to 9"

Speed — 33 strokes per minute

Center adjustable from 16" to 60"

This 600-ton Birdsboro Gag Press helps to speed production by straightening round and square steel bars of any size up to 9 inches.

Featuring a speed of 33 strokes per minute and stationary dies adjustable from 16" to 60" centers, this Gag Press was delivered *complete* with auxiliary equipment . . . motor-operated loading device, entering and delivery tables, manipulator for turning round and square bars, push-offs and cradles.

It *pays* to consult Birdsboro when *you* have a mill equipment problem.

BIRDSBORO STEEL FOUNDRY AND MACHINE COMPANY

Plants at Birdsboro and Reading, Pa.

BUILDERS OF: Steel Mill Equipment • Hydraulic Presses • Rolls • Special Machinery • Crushing Machinery

BIRDSBORO

STEEL MILL EQUIPMENT

Stop Oil Raids On Production

Dripping oil slows down production because it leaks from bearings which heat up, then waste power and wear excessively. It drips and spatters on your product requiring extra expense for removal.

NON-FLUID OIL does not drip. It stays where applied and keeps machines running smoothly at top speed. By lubricating dependably and outlasting oil many times NON-FLUID OIL assures low maintenance cost.

Used successfully in leading iron and steel mills. Send for instructive bulletin.

•

New York & New Jersey Lubricant Co.

Main Office: 292 Madison Ave., New York, N. Y.

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NON-FLUID OIL
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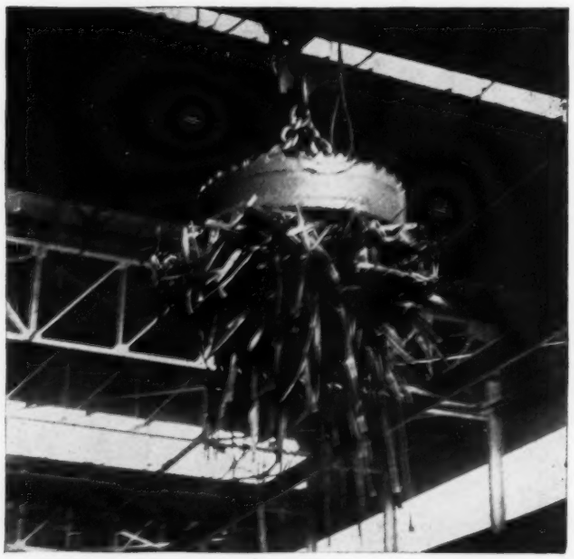
MODERN STEEL MILL LUBRICANT

Better Lubrication at Less Cost per Month

OHIO
Maximum Lift MAGNETS



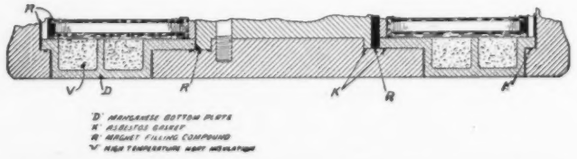
The Ohio 6 pancake coil magnet in the 55 and 65″ sizes will lift 35% more material on the average than the standard magnet.

The 8 pancake coil 55″ and 65″ magnets will lift 75% more than the standard magnets.

Labor cost per ton and time required to handle are both reduced correspondingly.

One large steel company bought a 6 coil 55″ magnet. It bought three more the next month, then two more and now has 12 of them.

★When Ohio magnets are required to handle hot materials we can supply them with hollow bottom plate. Hollow spaces are filled with heat resisting material. See cut below.



D' MANGANESE BOTTOM PLATE
K' ASBESTOS GASKET
R' MAGNET FILLING COMPOUND
V' HEAT TEMPERATURE HEAT INSULATION

Such magnets can handle hot material all day.

Have you a fast lifting or hot lifting problem?

The OHIO Electric Mfg. Co.

5907 Maurice Avenue — Cleveland, Ohio

For Economical Material Handling

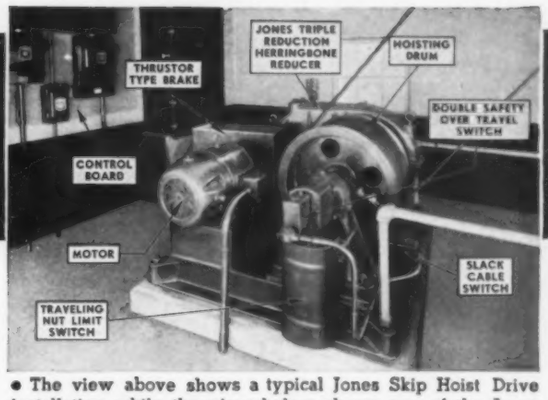
JONES SKIP HOIST DRIVES

FOR speedy operation, reliable service and over-all economy the Jones Skip Hoist Drive has made a name for itself in a wide variety of material handling service. These skip hoist drives are built as complete units by the Jones organization in several types with base to take any motor specified by the purchaser. They are equipped for all the modern protective devices such as cam or nut type limit switches, solenoid or disc type brakes and slack cable switches. The drives are single, double, or triple reduction Jones Herringbone Speed Reducers, built to stand up under the many years of pounding that a skip hoist drive has to take. The shafts are supported in roller bearings, with rolling action, rack generated gear and pinion teeth to insure easiest possible starting with low starting-peak loads. All reducer bearings and gears are automatic oil-bath lubricated.

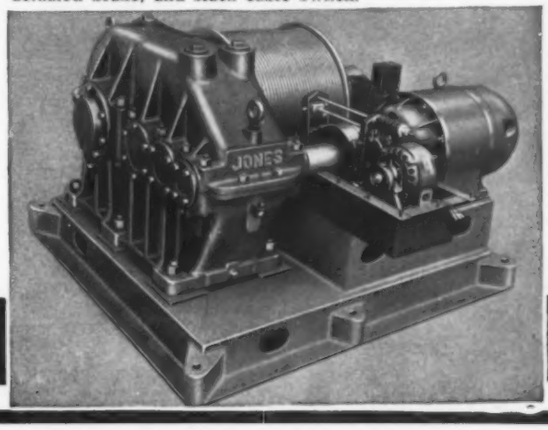
The Jones organization has an extensive file of information on skip hoist drive problems and will be pleased to work with you on any problems involving such applications

W. A. JONES FOUNDRY & MACHINE CO.
4431 Roosevelt Road, Chicago, Illinois

Jones HERRINGBONE—WORM—SPUR—GEAR SPEED REDUCERS
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES
ANTI—FRICTION PILLOW BLOCKS • PULLEYS
FRICTION CLUTCHES • TRANSMISSION APPLIANCES

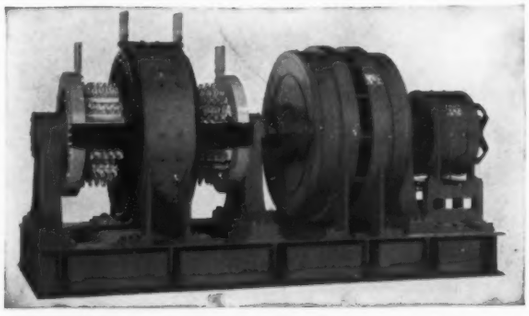


• The view above shows a typical Jones Skip Hoist Drive installation while the view below shows one of the Jones units equipped with traveling nut type limit switch, motor actuated brake, and slack cable switch.



Increase Production—Improve Quality

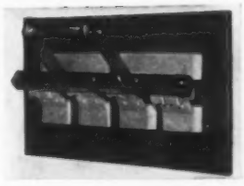
WITH THESE QUALITY - ADE COLUMBIA PRODUCTS

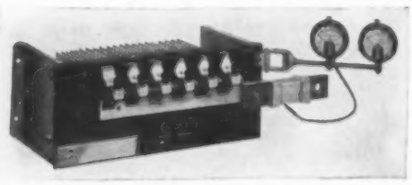


In these days of speed, speed, speed, you'll want to know the facts about Columbia Low Voltage Generators, Plating Tank Rheostats and Reversing Switches. For more than 15 years these Columbia products have been meeting the production and quality demands of the plating industry and, of relatively equal importance, we have them available now for prompt shipment.

Write us your needs and we will send you complete information immediately.

Columbia Low Voltage Generators are built in sizes of 100 to 20,000 amperes, 6 to 60 volts. They are available for electroplating service in sizes of 6 to 20 volts, 500 to 20,000 amperes; for anodic treatment of aluminum in sizes of 30, 40, 50 and 60 volts, 500 to 5,000 amperes.
Columbia Reversing Switches are of the double pole, double throw type for use as reversing switches or series parallel switches on circuits up to 15 volts, 200 to 2,000 amperes.
Columbia Rheostat sizes range from 15 to 5,000 amperes and with a 3 to 6 volt drop.





COLUMBIA ELECTRIC MFG. CO., 4512 Hamilton Ave., Cleveland, Ohio

LOW VOLTAGE GENERATORS **COLUMBIA** **PLATING TANK RHEOSTATS**
REVERSING SWITCHES

A. C. S. R. lines all over the country carry power to fighters on the home front.

Proper maintenance helps assure an uninterrupted flow of power to war industries. Hi-line or rural line, it must be kept in service to help fighters on the home front get supplies to our boys at the battle front. Your lines certainly earn the attention that's needed to keep them on the job.

The Government has recognized this need and permits the purchase of maintenance materials for power lines under ruling P-46.

You're not seeing much of the Alcoa men today who used to spread the gospel of Aluminum Cable Steel Reinforced; they're assisting in the production of vital Aluminum Alloy war materials. But this doesn't mean we've forgotten you. If you're needing advice, Alcoa engineers are ready to serve you.

Write ALUMINUM COMPANY OF AMERICA, 2128 Gulf Building, Pittsburgh, Pennsylvania.

ALCOA ALUMINUM A.C.S.R.

A·C·S·R *Aluminum Cable Steel Reinforced*

ON RURAL POWER LINES AND HI-LINES

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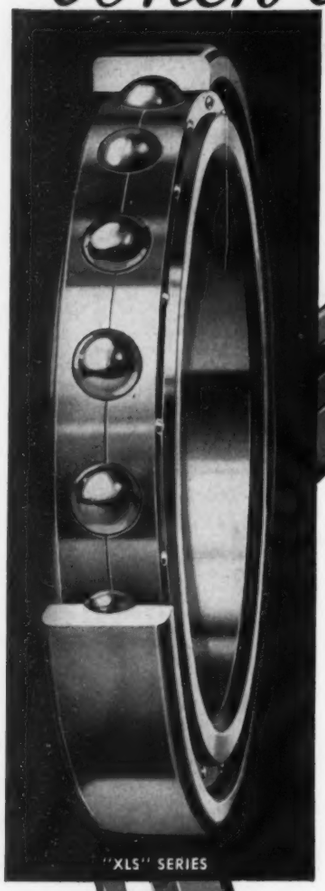
When You're Cramped for Space

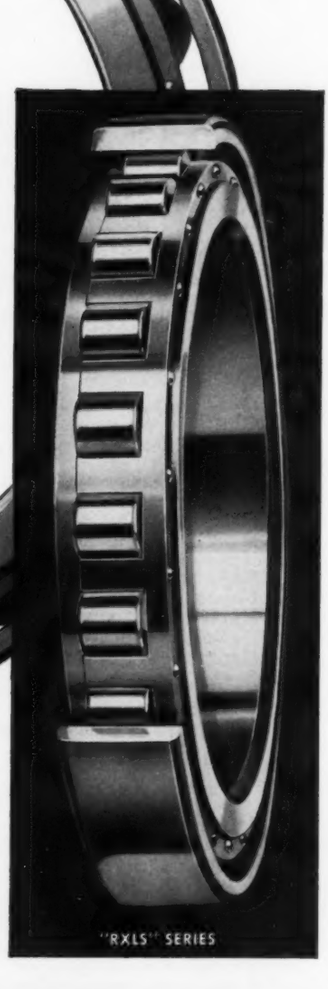
USE THESE VERY LIGHT INCH SERIES BEARINGS



HAVING bores abnormally large, as compared with the outside diameter, they offer definite advantages under certain conditions found in machine design. You may have them in several different types, *affording compactness, light weight, and greater latitude in your design.*

There are several lines of very light type ball bearings, which include the "S" starting at 1/8" bore, and the "XLS" starting at 1 3/8" bore, running up to a maximum of 21" bore and 28" outside diameter. And in very light type roller bearings, there is the "RXLS" Series, paralleling the "XLS" in size range.

Why not let our engineers tell you more about these Very Light Precision Bearings? Write for the Catalog.

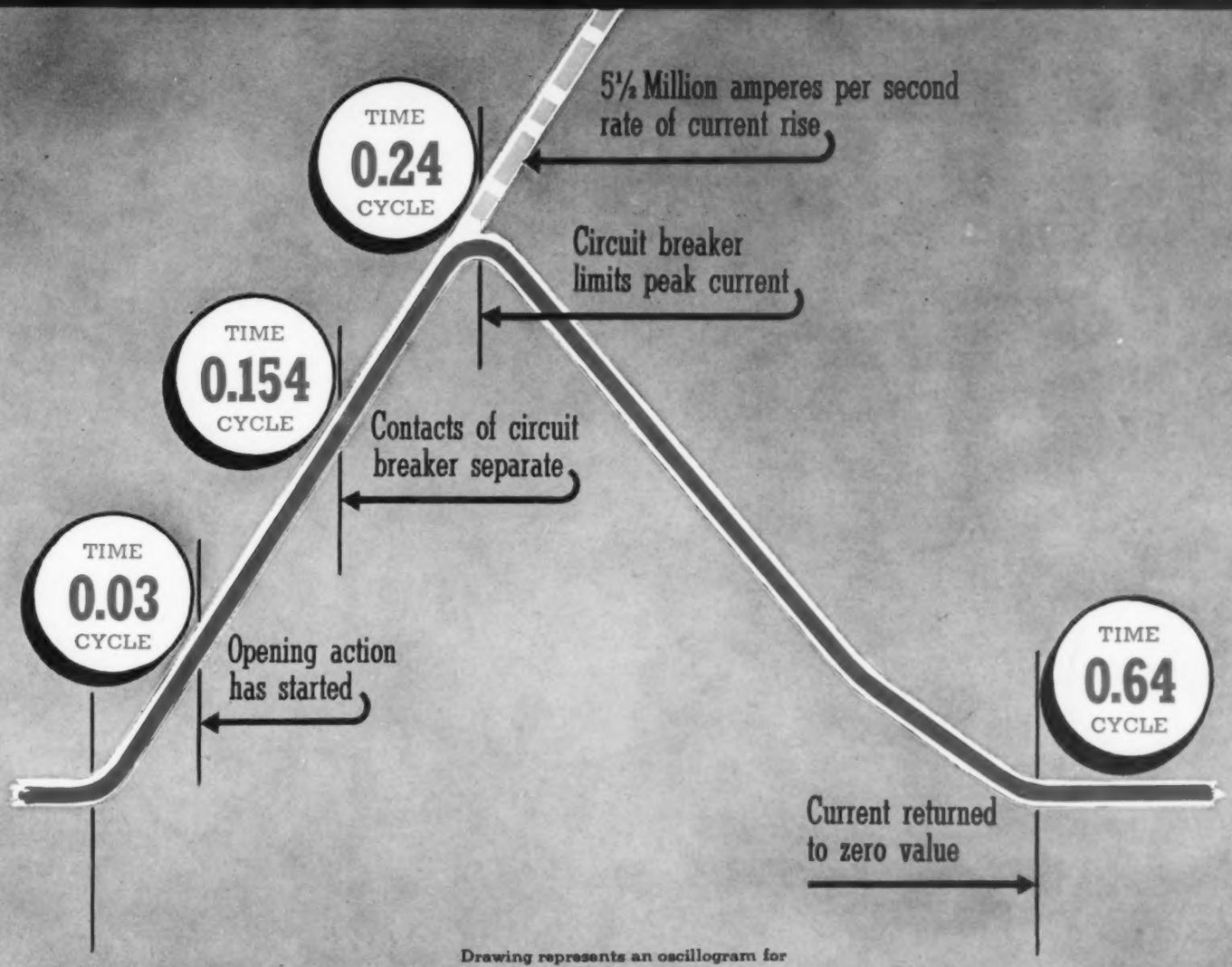


"NORMA-HOFFMANN"

PRECISION BALL, ROLLER AND THRUST BEARINGS

NORMA-HOFFMANN BEARINGS CORP'N.—STAMFORD, CONN., U. S. A.

Circuit Breakers that Really Open Fast



Drawing represents an oscillogram for
I-T-E Type DB-2 Circuit Breakers
CYCLE = 1/60 second

Far Surpassing the Best of Conventional Speeds

The fastest of conventional circuit breakers are capable of completing their opening action in approximately 1 cycle. Peak current is limited, in what is even now the best of common practice, to values attained in a period of about ½ cycle.

When engineers in industry were laying plans for using mercury-arc rectifiers arranged in parallel, the best of conventional opening speeds was foreseen to be inadequate for protection against backfires.

The I-T-E staff worked closely with engineers who were facing the new protective problem . . . . and the I-T-E Type DB-2 circuit breaker was the result.

Opening characteristics of the new circuit breaker are indicated above. Current rising at the rate of 5½ million amperes per second is limited, in this typical application, to the entirely safe value of 22,000 amperes. Peak current is reached in the record time of just less than ¼ cycle.

I-T-E will gladly send to engineers who identify themselves and their companies, copies of Bulletins 4205 and 4206 in which the circuit breaker and the application are described as fully as present conditions permit.

I-T-E

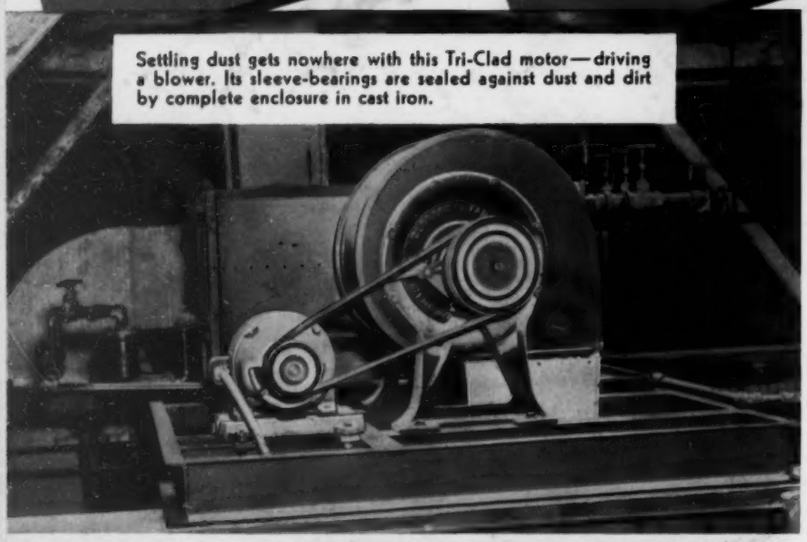
AIR SWITCHGEAR

IMMERSED IN AIR • ENCASED IN STEEL

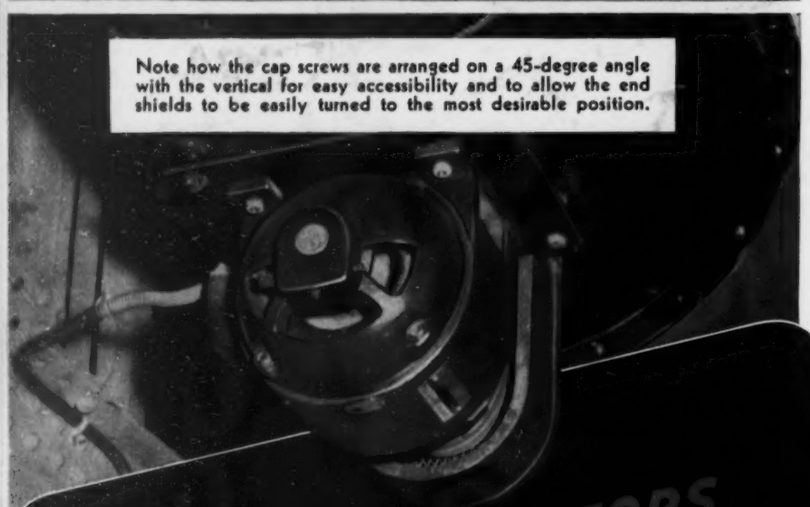
Representatives in Principal Cities

CIRCUIT BREAKER CO., PHILADELPHIA, PA.

YOU TOO CAN SAVE TIME... TROUBLE



Settling dust gets nowhere with this Tri-Clad motor—driving a blower. Its sleeve-bearings are sealed against dust and dirt by complete enclosure in cast iron.



Note how the cap screws are arranged on a 45-degree angle with the vertical for easy accessibility and to allow the end shields to be easily turned to the most desirable position.

... by using TRI/CLAD MOTORS

REG. U.S. PAT. OFF.

on your FANS and BLOWERS

MANY fans and blowers must be installed high above the factory floor, or in awkward locations where working space is limited. Here's where the Tri-Clad motor becomes a real time-saving aid to hard-pressed installation crews hurrying to get vital equipment into production.

Tri-Clad motors are a cinch to install because of their light weight and compactness. Also, their shape facilitates ease of handling, by hand or with slings. Four-position end shields permit flexibility in mounting, and the roomy four-position conduit box affords unrestricted working space. All leads are permanently identified. In addition, Tri-Clad features facilitate lubrication and other routine maintenance.

Specify Tri-Clad motors on your next order. You, too, will find that they save precious man-hours when you're installing equipment essential to the war program.

BUILT FOR PROTECTION FIRST . . . TO LAST!

General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance.

SPECIFY TRI CLAD MOTORS

1. *Extra Protection* AGAINST PHYSICAL DAMAGE
2. *Extra Protection* AGAINST ELECTRICAL BREAKDOWN
3. *Extra Protection* AGAINST OPERATING WEAR

Tri-Clad motors are now available up to 100 hp in standard, open construction, and in a wide range of other types and ratings. Ask your G-E representative for complete details, or write General Electric, Schenectady, N.Y.

Here again, light weight and convenience in mounting and lubrication are important advantages of this Tri-Clad motor driving an exhaust fan.

GENERAL ELECTRIC

750-117-8068